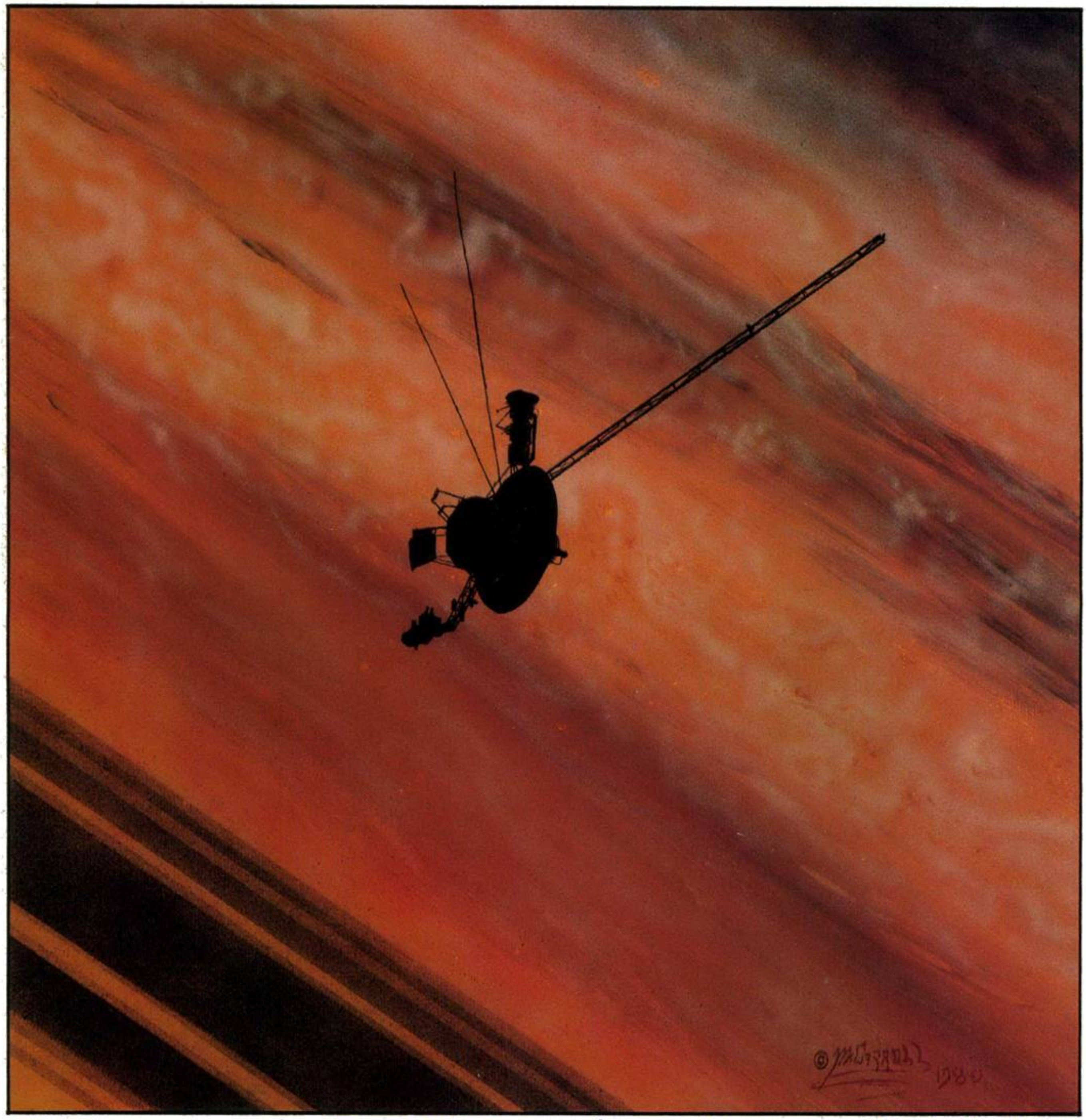
# ASTRONOMY

October 1981
$2
UK 95p

## Local Galaxies: the Magellanic Clouds

## 1981 Telescope Buyer's Guide

## How to Start an Astronomy Club



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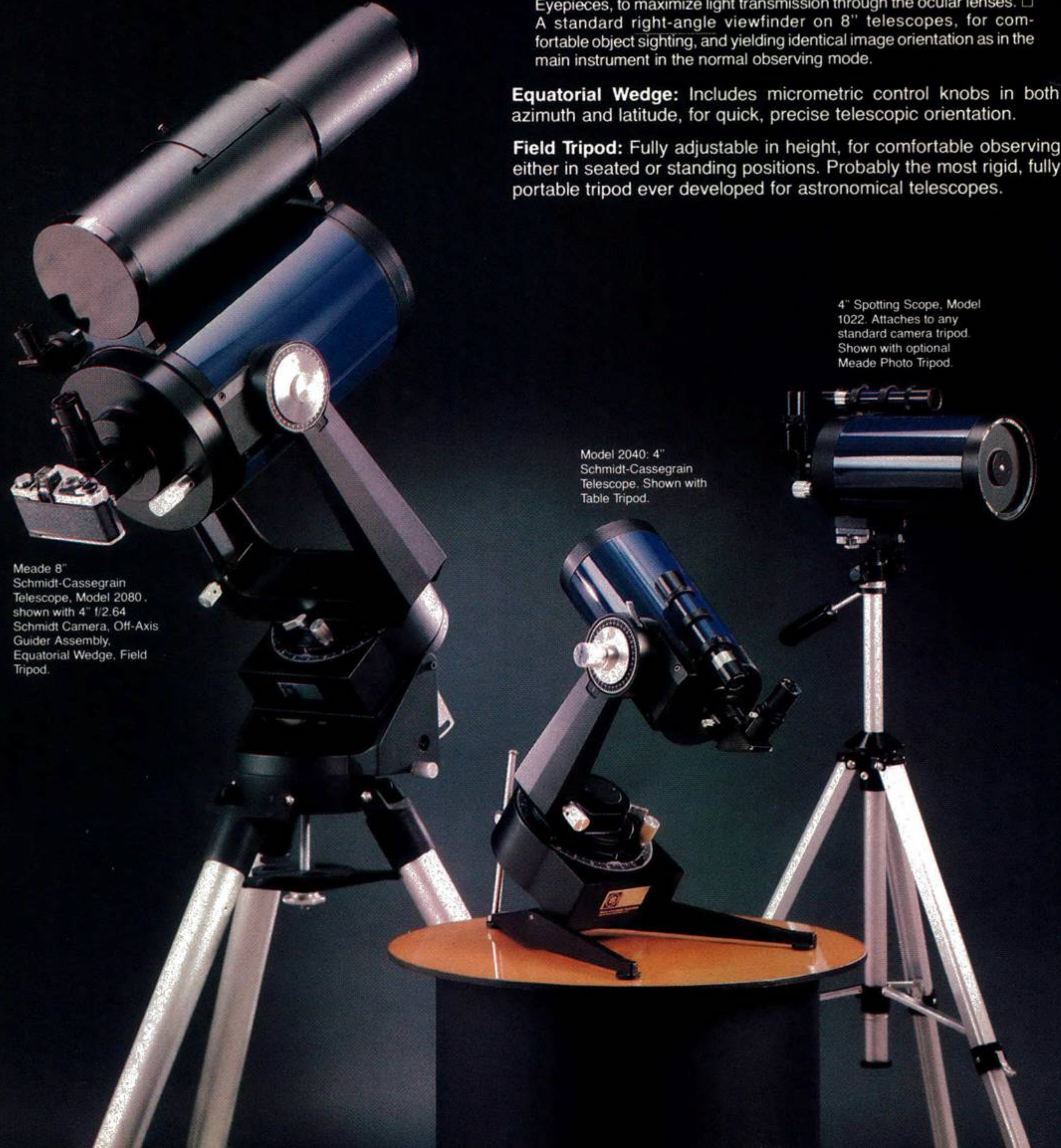

Meade 8" Schmidt-Cassegrain Telescope, Model 2080, shown with 4" f/2.64 Schmidt Camera, Off-Axis Guider Assembly, Equatorial Wedge, Field Tripod.

Model 2040: 4" Schmidt-Cassegrain Telescope. Shown with Table Tripod.

4" Spotting Scope, Model 1022. Attaches to any standard camera tripod. Shown with optional Meade Photo Tripod.

# Schmidt-Cassegrains

**The System:** Perhaps most importantly of all, Meade System 2000 Schmidt-Cassegrains are part of a wide and versatile system: the amazing 4" f/2.64 Schmidt Camera; 4" Schmidt-Cassegrain Photo-Guide Telescope with Illuminated Reticle Eyepiece; Dual-Axis Drive Corrector, and more — all of which attach easily and directly to 8" models.

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## PRICE LIST

| | |
|---|---|
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| 4" Schmidt-Cassegrain Telescope with Fork Mount ...... Base Price | **$595** |
| **Model 2080:** | |
| 8" Schmidt-Cassegrain Telescope with Fork Mount ...... Base Price | **865** |
| Equatorial Wedge 4"/8" | **60** |
| Field Tripod 4"/8" | **160** |
| Table Tripod 4" | **40** |
| Table Tripod 8" | **50** |
| **Model 1020:** 1000mm f/10 Telephoto Lens | **325** |
| **Model 1022:** 4" Spotting Scope | **395** |
| Meade Photo Tripod for Models 1020 or 1022 | **50** |
| **Model 2066:** 4" f/2.64 Schmidt Camera | **435** |

All prices include packing. Complete telescopes are packed in luggage-quality foam-lined carrying cases. All prices F.O.B. Costa Mesa, California. Calif. residents add 6% sales tax.

**Catalog:** Send $3.00 (Outside North America $5.00 for air mail) for your copy of the new 52-page Meade Color Catalog **No. 81-C**, with full details on Meade Schmidt-Cassegrains, Newtonian reflectors, refractors, accessories.

**Orders:** May be placed by mail, or by telephone at **(714) 556-2291**, or visit our Costa Mesa factory/showroom.

**Meade Instruments Corporation**

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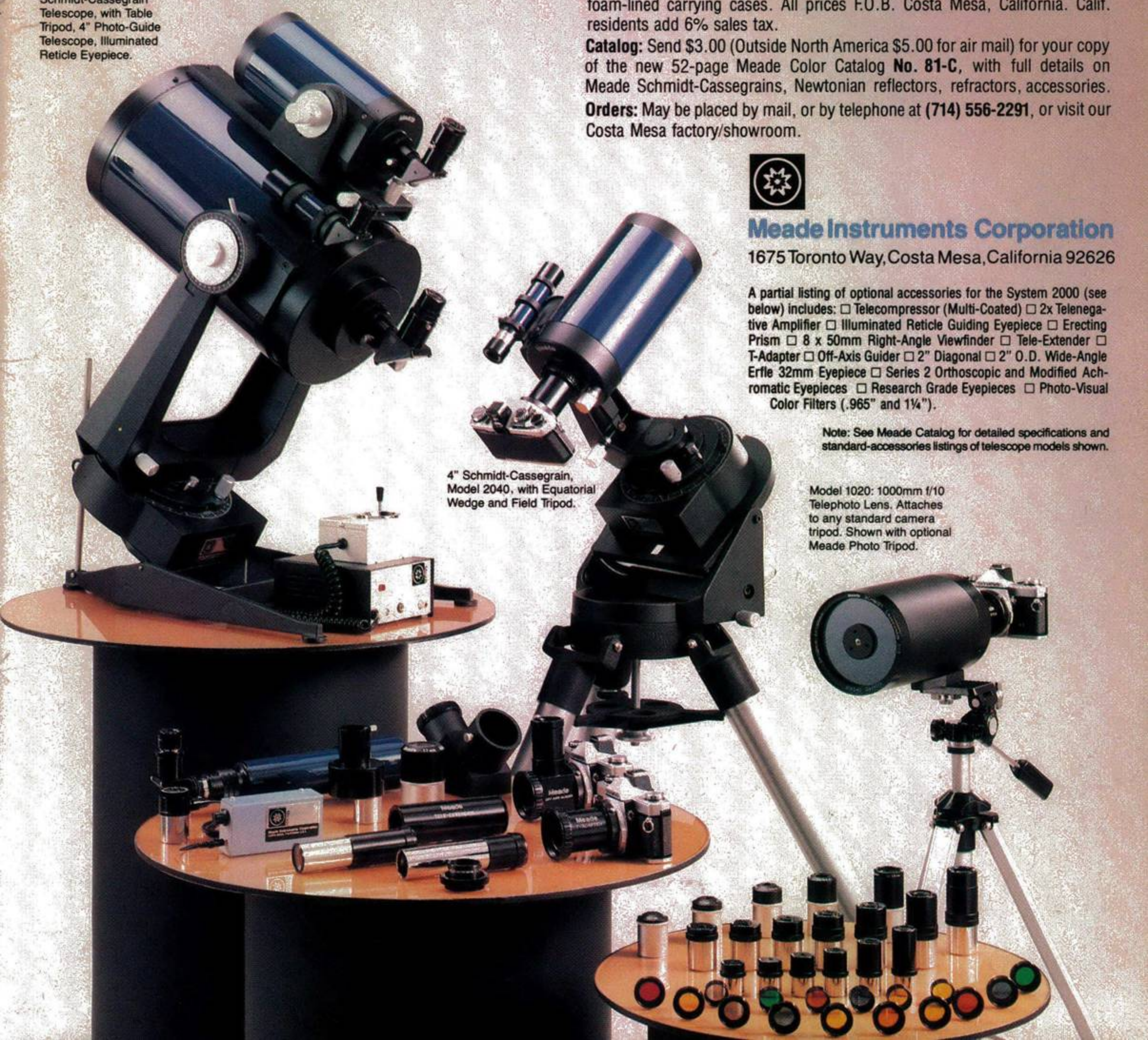
A partial listing of optional accessories for the System 2000 (see below) includes: ☐ Telecompressor (Multi-Coated) ☐ 2x Telenegative Amplifier ☐ Illuminated Reticle Guiding Eyepiece ☐ Erecting Prism ☐ 8 x 50mm Right-Angle Viewfinder ☐ Tele-Extender ☐ T-Adapter ☐ Off-Axis Guider ☐ 2" Diagonal ☐ 2" O.D. Wide-Angle Erfle 32mm Eyepiece ☐ Series 2 Orthoscopic and Modified Achromatic Eyepieces ☐ Research Grade Eyepieces ☐ Photo-Visual Color Filters (.965" and 1¼").

Note: See Meade Catalog for detailed specifications and standard-accessories listings of telescope models shown.



Model 2080: 8" Schmidt-Cassegrain Telescope, with Table Tripod, 4" Photo-Guide Telescope, Illuminated Reticle Eyepiece.

4" Schmidt-Cassegrain, Model 2040, with Equatorial Wedge and Field Tripod.

Model 1020: 1000mm f/10 Telephoto Lens. Attaches to any standard camera tripod. Shown with optional Meade Photo Tripod.

# ASTRONOMY

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**Cover:** Voyager swings past Saturn. Shutters click, instruments analyze the planet's radiation, and radios return data to a waiting Earth — then silence. Painting by Michael Carroll. These pages: The lunar eclipse of July 16 was visible throughout North America and was seen by millions of people. Greg Berns took this photograph just after first contact through a 6-inch Newtonian reflector, with Ektachrome 200 film and a 1/30-second exposure.

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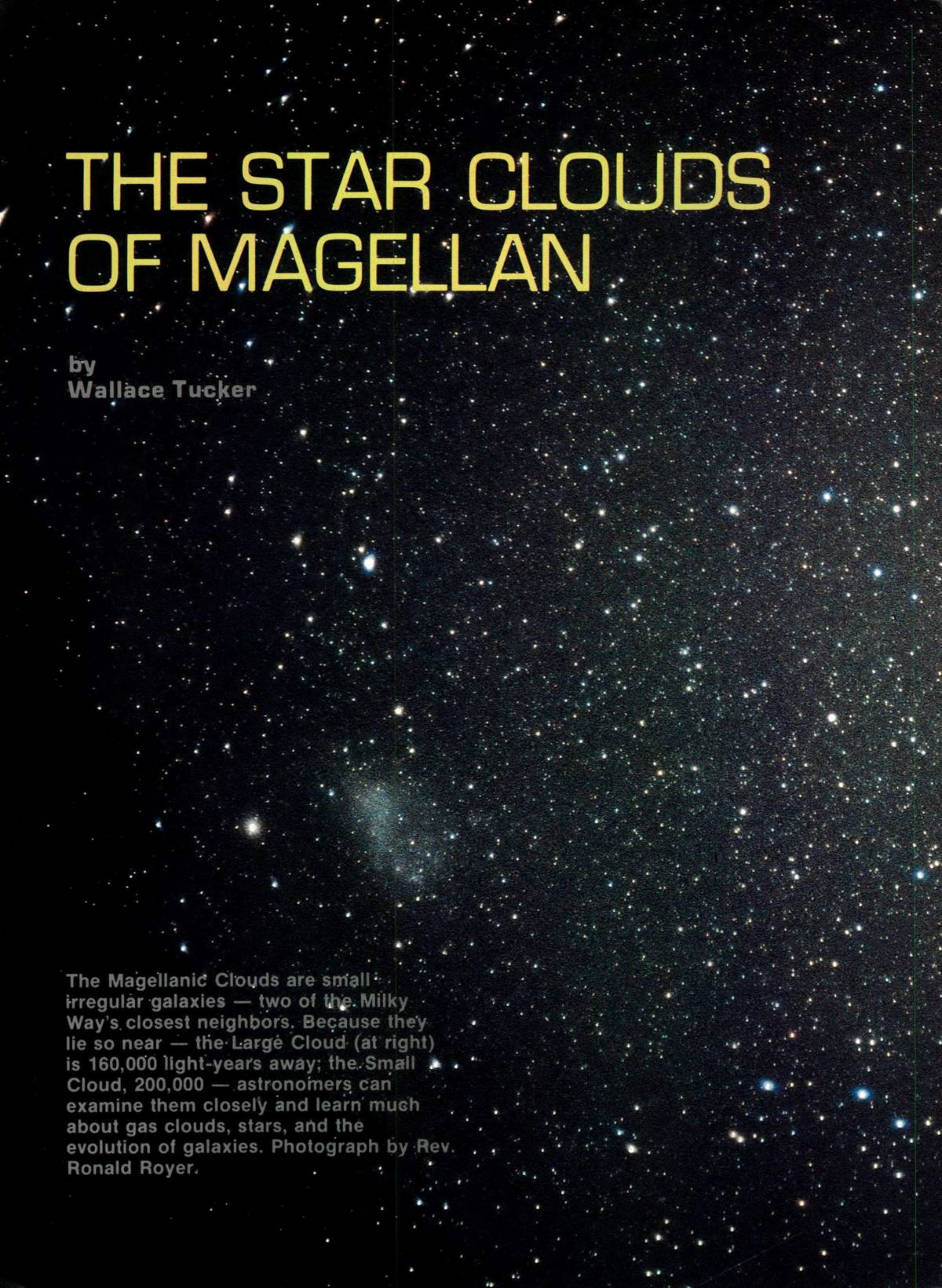
# THE STAR CLOUDS OF MAGELLAN

by
Wallace Tucker



The Magellanic Clouds are small irregular galaxies — two of the Milky Way's closest neighbors. Because they lie so near — the Large Cloud (at right) is 160,000 light-years away; the Small Cloud, 200,000 — astronomers can examine them closely and learn much about gas clouds, stars, and the evolution of galaxies. Photograph by Rev. Ronald Royer.

Through the ages, one of the primary aims of astronomers has been to define more clearly our place in the universe. One way they've done this is by going after the big picture — stretching their powers of reason and their equipment to seek out the edge of the universe and expand the boundaries of the known. They've also used another method, more introspective at least in a cosmic sense: The return to our galactic neighborhood. This approach allows astronomers to observe with a keener eye — sharpened by their more distant probes — the variety, the peculiarities, and the enigmas of the old "home town."

The Magellanic Clouds are an ideal target for this close-to-home look. Though they are not part of our Milky Way Galaxy, they are members of our Local Group and similar enough to our home Galaxy to lend us insights into its origins and composition. These galaxies, which to the naked eye look like detached portions of the Milky Way, have been described by Bart Bok as "the crown jewels of the southern skies." Since they are not visible from latitudes north of about +10°, they did not appear on European maps of the heavens until the late 15th century. They were named after the famous navigator, Ferdinand Magellan whose voyages expanded maps of the heavens as well as the Earth.

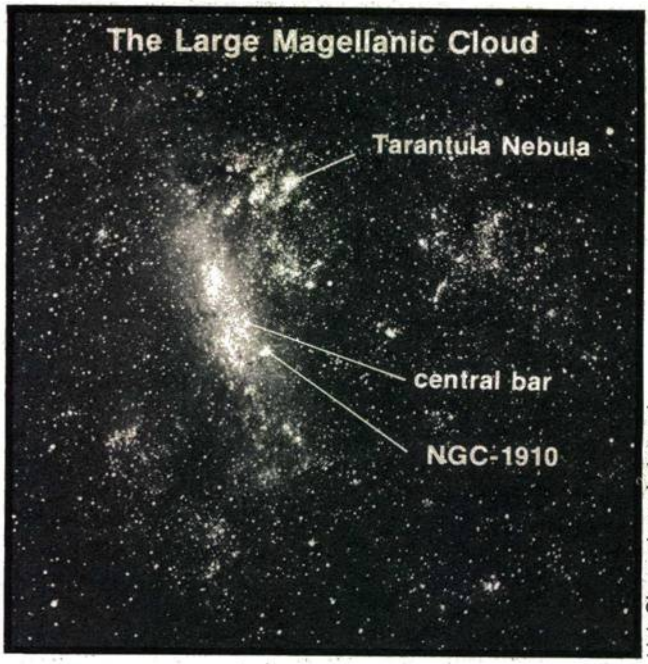
The Large Cloud has an apparent diameter of about 6°, or some 12 times that of the Full Moon. About 22° to the west (roughly the angular spread of a 12-inch ruler held at arm's length) lies the Small Cloud. Its angular diameter is 2½°, about five times that of the Full Moon. After the Milky Way itself — and discounting the occasional comet — the Clouds have the largest apparent size of any naked-eye object in the night sky. This is due both to their great physical bulk and their closeness to our Galaxy. The Large Cloud lies about 160,000 light-years from the Sun, the Small Cloud a little farther at about 200,000 light-years. They are among the Milky Way's nearest neighbors.

Astronomers classify the two Magellanic Clouds as "irregular" galaxies, a catch-all term for those somewhat shapeless galaxies that don't fit neatly into a spiral or elliptical category. The Small Cloud is unquestionably irregular, but although the Large Cloud also seems so at a casual glance, there's good evidence that it rotates and contains the rudiments of a spiral structure.

If the clouds were viewed from deep space, they would appear to be small satellites of the Milky Way. Both have low velocities relative to our home Galaxy and are probably "bound" to it by gravitational attraction. This configuration resembles that of the Great Galaxy in Andromeda (M-31) which also has two satellite-galaxies — M-32 and NGC-205.

How long have the Clouds been associated with our Galaxy? Have they always been there — or are they cosmic newcomers? What have the effects of the association been? Some astronomers think the Magellanic Clouds have orbited the Galaxy for billions of years. During this time, they have been gradually disrupted more and more by the gravitational tug of our Galaxy. According to this model, they will eventually be dragged down into the Milky Way and scattered into it. Others theorize that the Clouds have been captured recently — less than a billion years ago — in a close encounter that pulled out large clouds of hydrogen gas from the disk of the Milky Way.

**Left: Scattered along and just beside the "bar" of the Large Cloud are many ruddy clouds of hydrogen gas fired to luminescence by the radiation of the hot young stars within them. Such gas clouds mark where stars are presently forming. Photograph by Rev. Ronald Royer.**



Lick Observatory photograph

Whatever the case, we have a wonderful opportunity to study two magnificent nearby systems that contain billions of stars and vast clouds of gas. Since the Magellanic Clouds lie only one-tenth as far away as the Andromeda Galaxy, a 100-inch telescope turned to them is as effective as a 1000-inch telescope used on M-31 in Andromeda. With sensitive new detectors, even ordinary stars like our Sun — still totally out of reach in even the nearby galaxies — can be detected in the Magellanic Clouds.

The ability to see into the Clouds and pick out individual stars has been crucial for astronomy. They have provided an opportunity to compare directly the luminosities of supergiants, giants, main sequence stars of all types, Wolf-Rayet stars, Cepheid variables, eclipsing variables, RR Lyrae variables, globular clusters, novae, supernova remnants, and X-ray sources — all over a wide variety of ages and environmental conditions. This simply can't be done in our Galaxy. "At home," determining the distance to each individual object remains a difficult and time-consuming task, and beyond the Sun's immediate neighborhood, stars vanish into the murky dust of the galactic plane.

Away from the galactic plane and open to view, the Magellanic Clouds are a splendid laboratory for studying the grand cosmic cycle of stellar evolution: we can observe stars as they form out of clouds of gas, follow their evolution through nuclear burning, and witness the aftermath as the larger stars finally destroy themselves in supernova explosions. To close the cycle, we can see these explosions triggering, in turn, the formation of new stellar generations.

We also gain insight into the evolution of galaxies as a whole. The Magellanic Clouds weigh a tenth to a hundredth of what our Galaxy or the Andromeda Galaxy does, and this difference in mass has caused profoundly different shapes, different stellar populations, and different chemical compositions.

Of all the benefits of directly observing stellar luminosities in the Clouds, by far the most important has been the discovery of the "period-luminosity relation." For a certain type of variable star, Cepheids, the longer it takes to cycle through its brightness range, the brighter the star is on average. How this relation was discovered and what its effects have been makes a very interesting story.

Systematic photography of the Clouds began in 1899, and Henrietta Leavitt of the Harvard College Observatory was the first to search the plates for variable stars in the Clouds. In 1906 a catalog was published listing 808 variables in the Large Cloud and 969 in the Small Cloud. Six years later, Miss Leavitt published a report that showed how similar one group of variable stars in the Small Magellanic Cloud was to the famous naked-eye variable Delta (δ) Cephei. Her report also noted that the brightest Cepheid-like stars were those that took the longest to go through their cycle of variation. Since all the stars in the Cloud (including Cepheids) lie at roughly the same distance, astronomers knew the longest period variables were the most luminous intrinsically.

Another Harvard astronomer, Harlow Shapley, quickly grasped the significance of this relationship between period of variability and brightness. If you could measure the period of a Cepheid variable, he reasoned, you could tell how far away it was by comparing its apparent brightness (measured on a photograph) with its real brightness (derived from the law).

Cepheids are excellent distance calibrators; they are very luminous stars and can be seen at great distances. Although an unknown amount of absorption due to dust within the Clouds creates some uncertainty, the visual absorption in the "foreground" (our own Milky Way) is small — we see the stars pretty much as they actually are. Knowing the distance to a few Cepheids in our own Galaxy, Shapley established the distance to the Clouds. He then used Cepheids and other variable stars found in globular clusters to determine the size and structure of our own Galaxy. Later, Edwin Hubble used Cepheids to prove that the Andromeda and other nearby spiral "nebulae" are in fact distant massive galaxies much like our own.

In the years since, astronomers have identified over a thousand Cepheids in each of the Clouds and have modified the original period-luminosity relation to take into account two different types of Cepheids. But for all that, this simple yet deceptively powerful tool is fundamental in observational cosmology.

However, Cepheid variables are only one member of the Clouds' population of objects. Radio observations reveal that about 30% of the mass of the Small Cloud is hydrogen gas. By comparison, the mass of our Milky Way Galaxy is only about 3% hydrogen. Since hydrogen is the raw material from which stars form, it's natural that the Clouds should be full of hot, young, bright stars — as shown by their characteristic bluish tint.

Older red stars are also present in the Clouds. In the Large Cloud, they lie along a large "bar," which is conspicuously ruddier than the Cloud as a whole. Some of these are extremely luminous red supergiants — young and massive stars that have already burned much of their fuel and have evolved rapidly to the supergiant stage. Although the Milky Way contains many more red supergiants than the Clouds do, astronomers find it hard to study them because light-years of dusty gas separate us from all except the nearest and brightest. But out in the Clouds, away from the hazy galactic plane, supergiants are easy to observe.

The brightest stars in the Clouds have a luminosity of about a million suns each; astronomers, running out of superlatives, call these stars "super-supergiants." One such is S Doradus, a peculiar variable star located in NGC-1910, a brilliant cluster of giant and supergiant stars.

The apparent brightness of S Doradus changes irregularly by about two or three times. Some evidence in the way its light varies over the years indicates it may be an eclipsing binary system of two very large stars orbiting with a period of 40 years. Since the Earth happens to be in or near the plane of the orbit, twice each orbit we see one occult the other.

Theory suggests that the two stars each have masses of about 60 times the Sun's, and diameters some 1300 times that of the Sun. (If such a star were placed in the center of the solar system, its surface would lie out beyond the orbit of Jupiter!) But astronomers are not certain the eclipsing binary interpretation is right, although a predicted eclipse occurred on schedule in the late 1960s. The problem is that S Doradus shows irregular variations which *cannot* be attributed to eclipses. In recent years, the star has gradually faded: once the most luminous in the cluster, it has surrendered this title to another star, HD 33579.

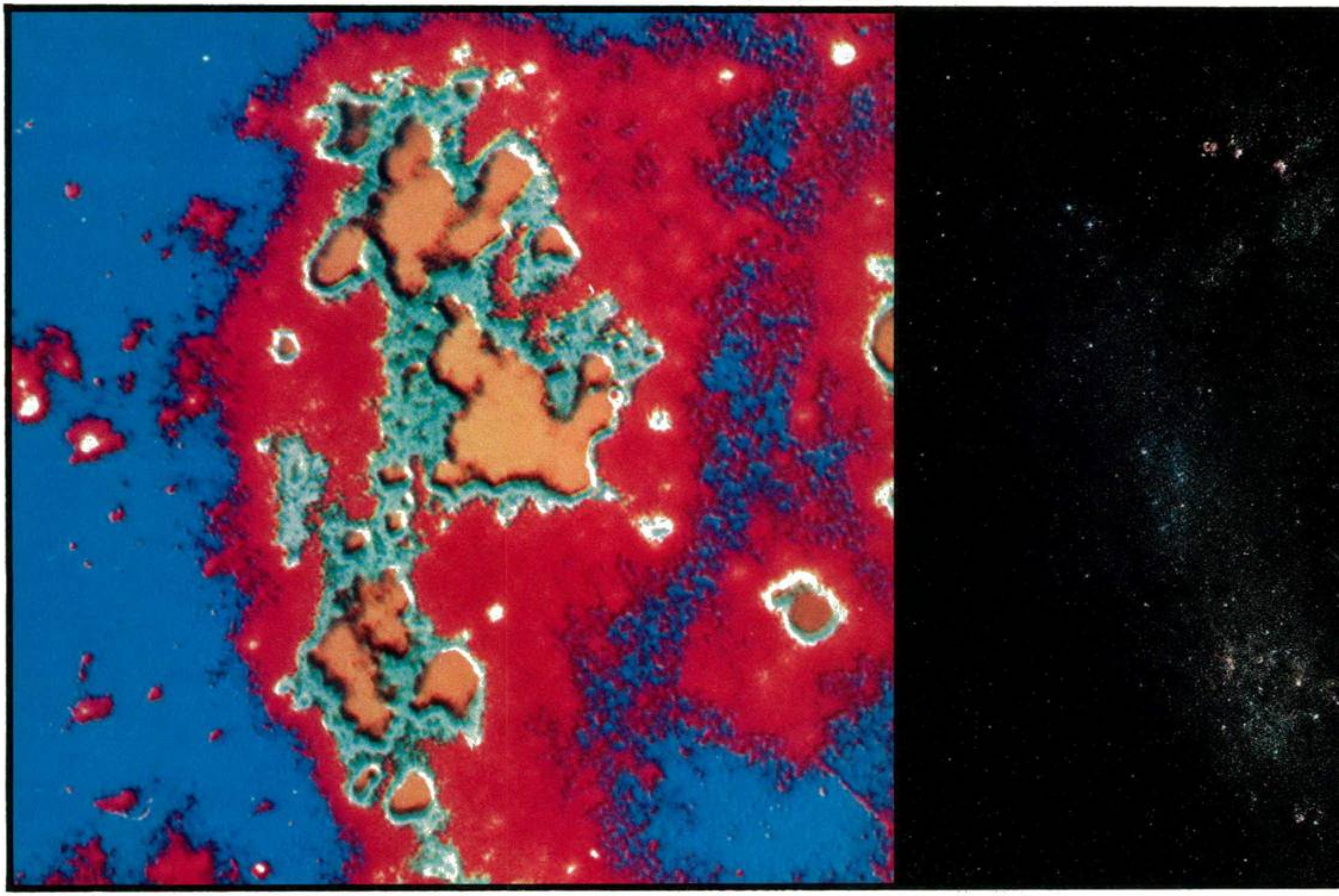
HD 33579 appears to be a star stretched to its limit. Although undoubtedly very massive, it is so extended that the gravity at its "surface" is a hundred times less than the gravity on Earth. (By comparison, the gravity on the surface of the Sun is 300 times higher than on Earth.) HD 33579 has a mass of 50 to 100 suns and a diameter almost 4,000 times as large.

But as spectacular as S Doradus and HD33579 are, both pale in comparison to the brilliance of R136, the object located at the center of the vast Tarantula Nebula. A series of short exposure, fine-grain photographs taken with the 3.6 meter European Southern Observatory telescope has shown that R136 in reality has three components, the brightest of which, R136a, is less than three light-years in diameter.

Knowing how far away the Tarantula Nebula is and how bright R136 appears, astronomers have tried to guess what it might be. Either 50 to 100 supergiant stars crowd together in a cluster less than three light-

**The Small *Magellanic Cloud* is less massive than the Large Cloud and has fewer nebulae, but a greater proportion of its mass is hydrogen gas. The bright "star" at the top of the page is the large globular cluster 47 Tucanae. Photograph © AURA/CTIO.**

NASA photograph



**Ultraviolet Light** **(all three have the same scale; east lies at top)** **Visible Light**

years across — something never before observed — or R136 is a single massive object with a brightness of 30 million Suns. (See AstroNews this issue.) For such an object to hold together against the pressure of its own radiation, it would need the mass of several hundred suns. With a mass that large, the object would burn up its nuclear fuel very rapidly and would exist for a million years or less — a mere wink of the eye in cosmic terms.

The nebula which R136 illuminates is no less awesome. Also known as 30 Doradus, the Tarantula Nebula is a complex of gas and stars stretching several thousand light-years in diameter and having no known equal in our Galaxy. If the Tarantula Nebula were as close as the Orion Nebula, it would be visible in daytime and would throw a shadow at night.

The Tarantula is also a strong source of radio emission. Part of its noise comes from gas heated by hundreds of supergiant stars in the nebula, and part from a strong central source. When astronomers analyze the radio spectrum of the source in the center of the nebula, they find emission from very high energy electrons. No one knows where these electrons come from, but supernova explosions — which surely must have occurred here in the past few thousand years — are a likely source.

If R136 is young, the bright supergiant stars are hardly much older: less than twenty million years. During this time, they have moved only a few hundred light-years — most still lie within the gas clouds where they formed. This gives astronomers a chance to observe what kinds of stars emerge from different types of clouds.

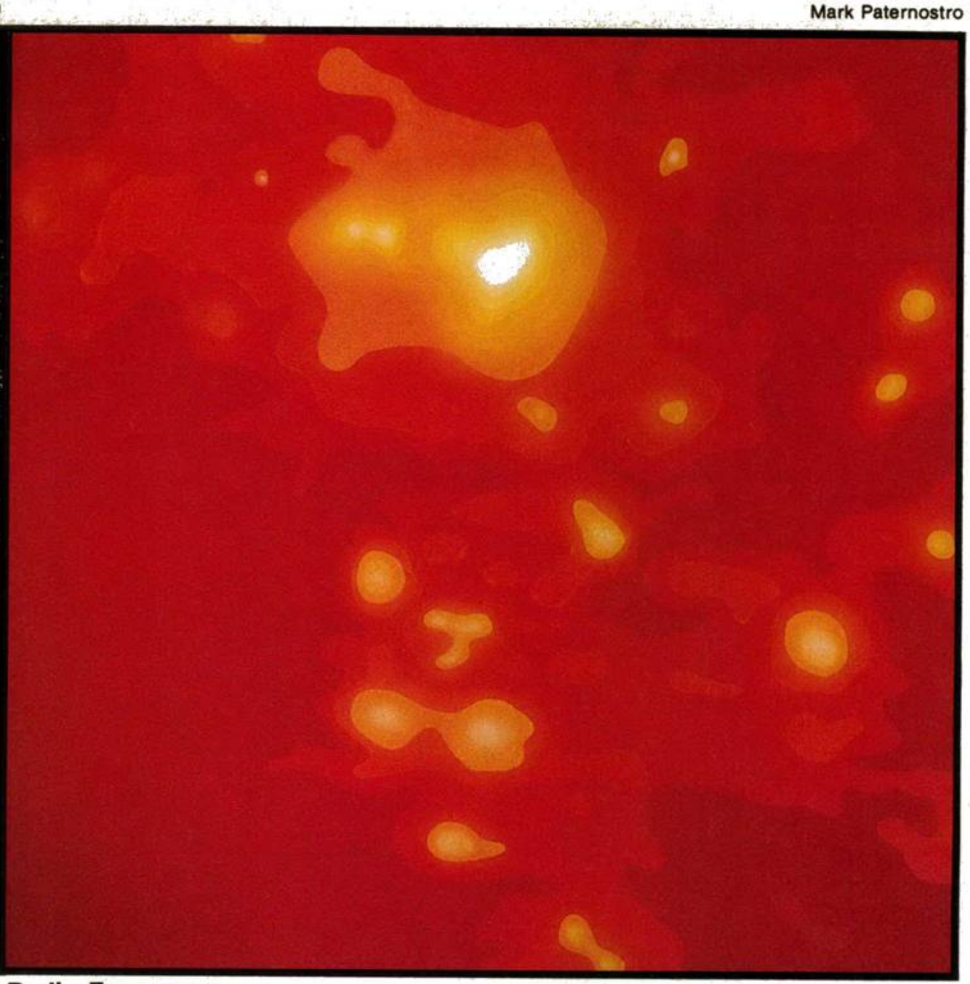
In our Galaxy, stars form out of clouds containing both hydrogen gas and dust, but little dust appears in the Magellanic Clouds. Because radiation from dust grains is important in cooling the gas-clouds that are collapsing into stars, astronomers want to study how stars can form in the Clouds without dust grains. In the very early stages of our Milky Way Galaxy, almost all of the material was hydrogen and little, if any, was dust. Research in the Clouds may provide some hints as to how stars came about in the dust-poor early days of our Galaxy.

Impressive as it is, the Tarantula Nebula doesn't exhaust the roster of star- and gas-clouds. Over 50 large clouds, each with enough gas to make a million suns, appear in radio observations. Radio surveys have also revealed another surprising phenomenon: "supershells." The Clouds contain four expanding shells of gas, each encompassing about 5,000 light-years and holding enough material to make 10 million suns.

Astronomers suspect that similar structures exist in our Galaxy, but identifying them with certainty is difficult because of the large angle of the sky to examine, and uncertainty over how far away they might be. Once again, our outsider's perspective on the Clouds comes to the rescue; out there, astronomers can clearly identify shells, measure their

AURA/CTIO photograph

Mark Paternostro



Radio Frequency

velocities and estimate their mass and energy content.

But understanding where these objects come from is another matter entirely. Apparently, an enormous blast or series of blasts — or maybe even "winds" and radiation from a cluster of supergiants — released as much energy as 100 supernovae into the interstellar medium some 10 million years ago. The resulting shock waves, spreading spherically outward, swept up matter across thousands of light-years.

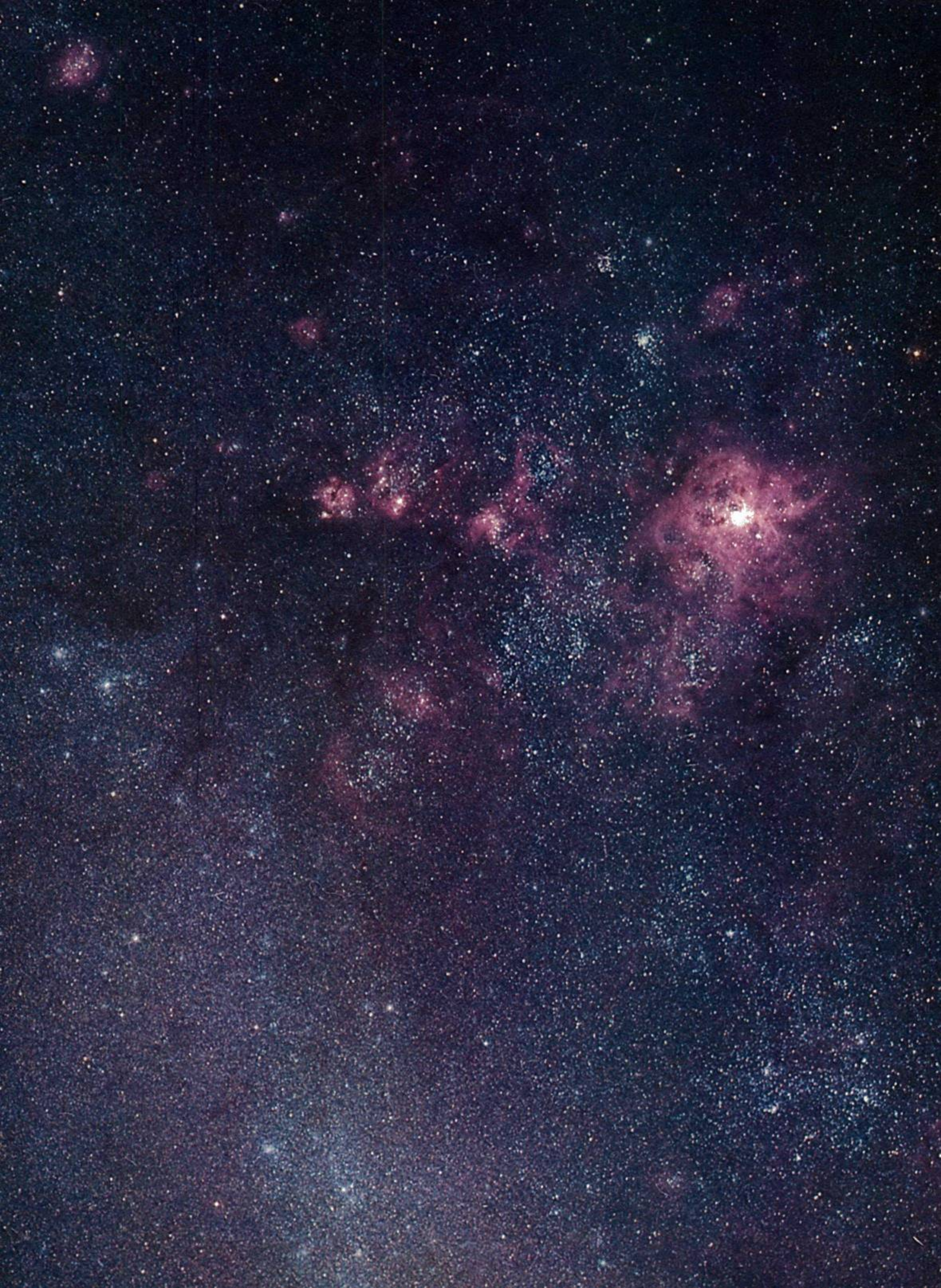
Was it a gigantic supernova — some kind of super-supernova? Even massive super-luminous giant stars like S Doradus appear inadequate to explain the energy of these shells. One rather dramatic possibility is a stellar chain reaction of supernovae. Imagine that a massive star supernovas inside a dense cloud. The explosion could trigger the cloud to collapse into a number of massive stars which would — over the next 10 million years — evolve quickly and in their turn explode. Then they too would trigger the formation of additional stars — and so on, until most of the gas cloud was used up or blown away. When astronomers understand fully what has happened in the supershells, we'll know a lot more about how stars interact with each other's evolution.

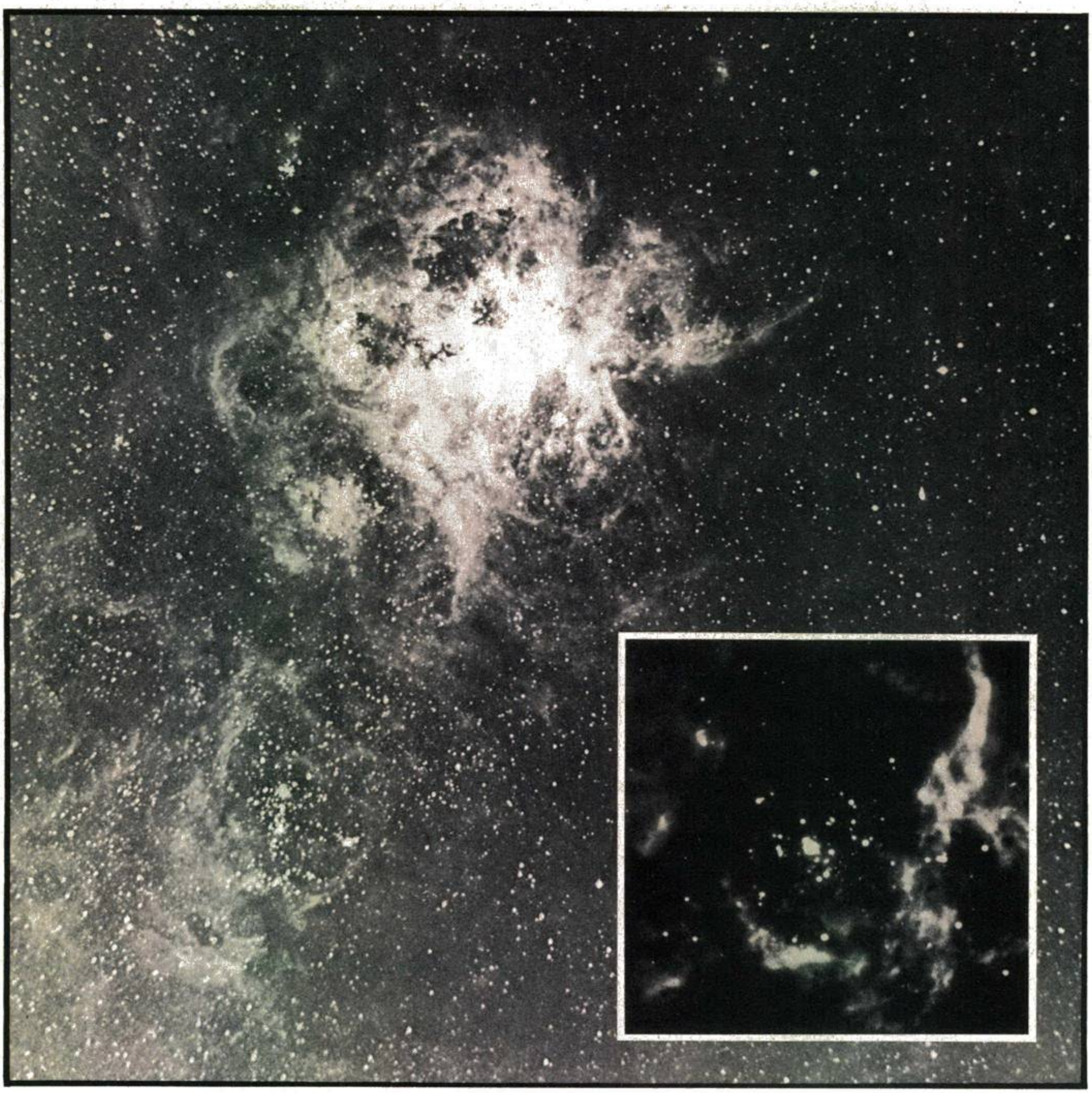
The overall structure and dynamics of the Magellanic Clouds appear clearest when observed in the radio region of the spectrum. Although there is still doubt about the precise shape of the Small Cloud, the Large Cloud appears to be a flattened system seen about halfway between edge-on and face-on. Depending on the angle that theoreticians assume for its inclination, the mass of the Large Cloud varies, but the best guess yields a figure of about 10 billion solar masses — about one-thirtieth the mass of the Milky Way. (It's coincidental, but the total mass of the Large Cloud is about the same as the mass of hydrogen gas in the Milky Way.) The Small Magellanic Cloud likely has only about one tenth the mass of the Larger Cloud.

Both Clouds may be a very early stage in the development of a regular, symmetric galaxy. But this observation raises a paradox, because some of the stars in the star clusters in the Magellanic Clouds are as ancient as the oldest stars in our Galaxy. How can this be?

The answer seems to lie in the density of gas and stellar material. The evolutionary pace of a galaxy — regardless of its age in years — depends mostly on how tightly packed the material within it is. Star formation proceeds most rapidly in high-density galaxies such as M-87 or M-32. The Magellanic Clouds have a much lower density than our Galaxy. Gas and stars are distributed unevenly and neither Cloud has a nucleus where densities run high. So, while they are as old as the Milky Way, our Galaxy's evolution has raced along and theirs has dawdled.

The lack of a distinctive nucleus may also have had a strong effect on the Clouds' structure and development. Galaxies with large central





**Left: The Large Cloud shows its "bar" and the region surrounding the red Tarantula Nebula. Photograph © AURA/CTIO. Above: With its spidery tendrils extending in all directions, it's easy to see how the Tarantula Nebula got its name. At its center (inset), hidden by light-years of glowing gas, lies a supermassive and superluminous object known as R136. Photograph from Yerkes Observatory, inset photo courtesy of the author.**

concentrations of mass tend to be more organized, have relatively smooth distributions of matter, and more or less uniform flow patterns. But in objects such as the Clouds, where no strong central gravitational hub is in control, matter will distribute itself willy-nilly in clumps and knots.

Jan Oort of the University of Leiden — who has done much to elucidate the structure of our Galaxy — suggests an analogy with political structures. "In objects like the Magellanic Clouds," he says, "without such a central government (a massive concentration in the nucleus) . . . the different provinces and states get too independent, and develop all on their own. . . ."

Another line of evidence underscores the evolutionary youth of the Clouds. Observations of atomic element abundances in them suggest that less nuclear processing of elements has happened there than in our Galaxy. The stars and gas of the Clouds show deficiencies of chemical elements such as nitrogen, oxygen, and sulfur by comparison with the Milky Way. Since virtually all of these heavy elements are produced in the interiors of stars, it clearly implies that fewer stars have been "active" in the Clouds. (See "Probing the Chemistry of Galaxies," ASTRONOMY, June 1981.)

The Milky Way Galaxy experienced an intense burst of star formation some 10 billion years ago when it was young. Much of its primordial hydrogen was

**About 22° of sky separate the Large Magellanic Cloud (seen at right) from the Small. Astronomers have found an envelope of faint, tenuous hydrogen gas that joins the two Clouds with each other and with the Milky Way. Photograph from Harvard College Observatory.**

used up in making stars, and about 3% of the stellar material has been processed into elements heavier than helium. After this early epoch, the rate of new star formation declined markedly, although vigorous star-forming regions still exist in the gas clouds (like the Orion Nebula) strung out along the spiral arms.

But in the Large Magellanic Cloud, the rate of star formation has stayed approximately constant. Although star formation there was less active in the past (compared to our Galaxy), it is more active now. In the Small Magellanic Cloud, star formation has been sluggish all along, which accounts for its very large proportion of hydrogen gas and low proportion of heavy elements and dust.

Star clusters also betray telltale signs of different evolutionary paths. Milky Way star clusters fall into two groups: globular clusters having millions of old, low-mass stars, and open clusters containing thousands of massive, young stars. The globulars surround the center of the Galaxy in a spherical halo while the open clusters spread through the disk. No such clear-cut difference exists in the Magellanic Clouds. They have halos of old globular clusters containing millions of stars, young clusters also with millions of stars, clusters of intermediate age, and young globular clusters containing tens of thousands of stars — none having an exact counterpart in our Galaxy.

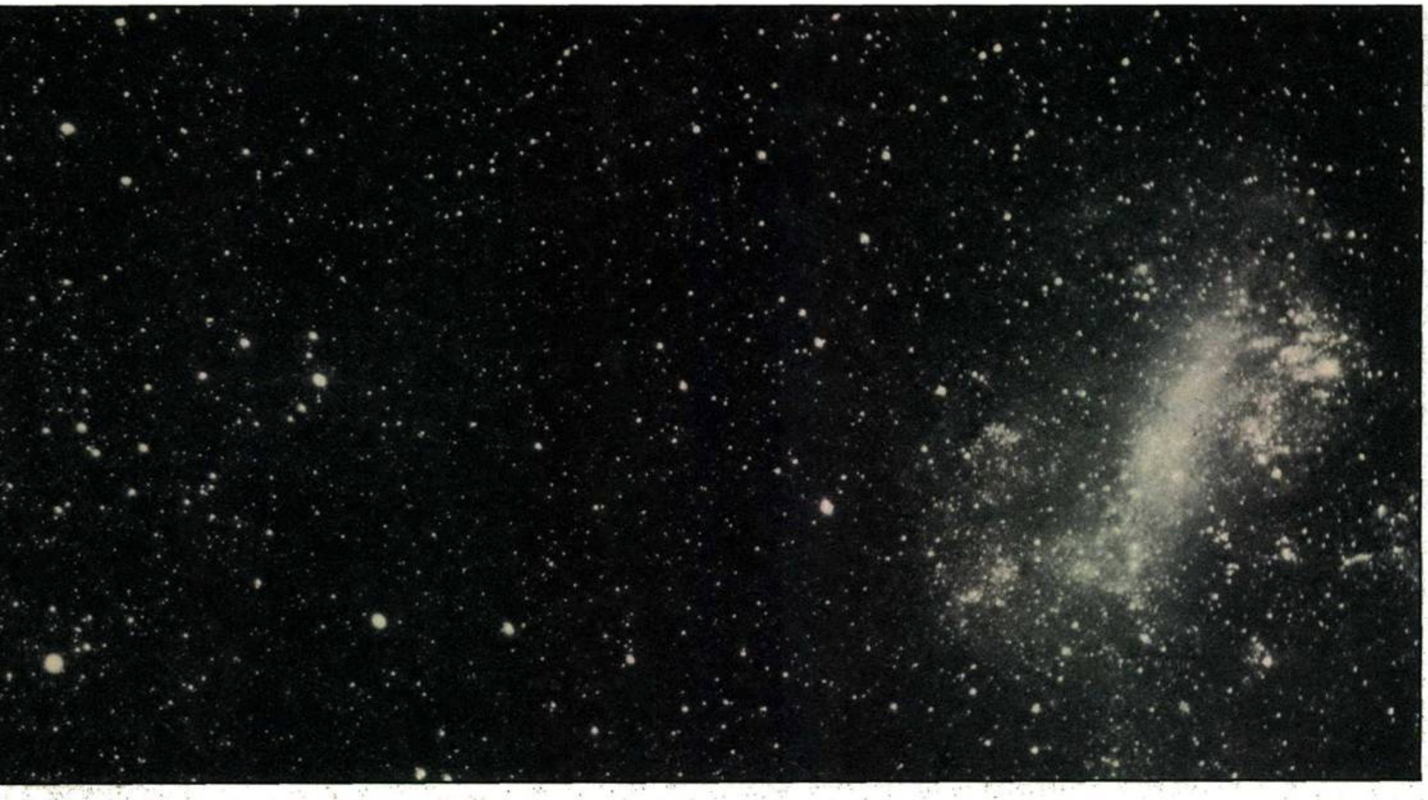
The difference in cluster types probably stems from two factors: a different star formation history and the different concentrations of mass in the central regions. In the early periods of our Galaxy's existence, there was no central mass to lure away material — globular star clusters could form and did. Later, when the pronounced central hub and the flattened disk developed, the depletion of material in the halo and the shearing motions in the disk favored smaller, looser, and less populous clusters.

In the Magellanic Clouds, the central concentration has always been weak. Thus, the shearing motions are weak also, and massive clusters can still form. Will these young clusters gradually be distorted into an irregular shape? Already a trend is evident. In the Large Cloud, the massive clusters such as 30 Doradus are irregular, whereas the young globular clusters in the "disk" are all comparatively small and contain only ten thousand stars each.

The Clouds' old globulars contain stars that are as old as the Galaxy. Have the Clouds always been associated with our Galaxy? Were they formed with it? Expelled from it? Are they "cosmic neighbors" just passing by? Let's look at the astronomical evidence.

The two Magellanic Clouds share a common envelope of hydrogen gas and a bridge of star clusters and gas connects them. In some respects, then, the Large and Small Clouds and the bridge clearly form one system. That the outer edges of the Clouds are fairly sharp, while the material between them streams diffusely, suggests they may be separating. To judge by the Clouds' velocities with respect to the Sun, such have assumed up to now. If the Clouds are more massive, they would hold together better and have more mass to warp the Milky Way. If the Galaxy has more mass, it could pull a stream of matter from the Clouds. Some evidence exists that a massive halo of

Meanwhile, a possible link between the Magellanic Clouds and the Galaxy has been found in the form of an enormous bridge of hydrogen gas — the Magellanic Stream — that extends from the Clouds part of the way to our Galaxy. Of several theories proposed to explain the stream, the most



widely accepted has been that of tidal interaction. In this model, our Galaxy ripped gas out of the Clouds during a recent close orbital encounter. Astronomers find this interpretation particularly attractive because it may explain another long-standing puzzle: the warped outer edge of the Galaxy.

But the hurdles in the way of a successful tidal theory are formidable. It must first explain the observed features of the stream by means of tidal forces of our Galaxy acting on the Clouds. At the same time, the theory cannot allow the Large and Small Clouds to be pulled apart completely in the last 5 billion years. Lastly, the theory has to show how tidal forces of the clouds warp the edge of the Galaxy.

As yet, no one has come up with a way to satisfy all three requirements simultaneously. If one model explains the stream and the warp, the Clouds get pulled apart. If another explains the warp and keeps the Clouds intact, there's no stream! Frustration has led some astronomers to propose that the Magellanic Clouds have passed through a hypothetical corona of hot gas surrounding our Galaxy. A turbulent wake resulted that cooled to form the stream. Unfortunately, calculations show that such a wake couldn't cool quickly enough to become the stream we now observe.

One solution to the dilemma drops the requirement that the Clouds warp the Galaxy's disk. Although this sounds suspiciously convenient, warps *do* exist in galaxies with no nearby neighbors — so perhaps our Galaxy's warp happened by some other yet unknown mechanism. Against this idea, a number of clusters of galaxies show gas streams between member-galaxies that have warps near the streams.

Another possibility — one which might allow all conditions to be met — is that both the Clouds and the Galaxy are much more massive than astronomers have assumed up to now. If the Clouds are more massive, they would hold together better and have more mass to warp the Milky Way. If the Galaxy has more mass, it could pull a stream of matter from the Clouds. Some evidence exists that a massive halo of dark material surrounds our Galaxy, but whether one also exists around the Clouds is little more than speculation at present. For now, it seems the problem of the Magellanic Stream must remain a nagging and unsolved riddle.

We haven't said much about the origin of the Clouds and with good reason — not much is known. Their low velocity with respect to the center of our Galaxy shows they must be bound to it by gravity. It's therefore unlikely that they were ejected from the nucleus of our Galaxy; if this were the case, they would have either escaped or fallen back in by now. As for whether the clouds formed independent of the Galaxy and were captured later, or formed along with the Galaxy — no one knows at present.

But we're far more certain about their ultimate fate. According to current ideas, the long-term future of the Magellanic Clouds is bleak, indeed. Dynamic friction will gradually decay their orbit, spiraling them into the Galaxy. In a few billion years, tidal forces will probably disrupt them. The night sky then will be dazzling as vast clouds of gas and stars drift into the Milky Way. Collisions between clouds of gas will trigger bursts of star formation. Supernovae will flare and die out. Brilliant new nebulae will blaze forth, visible by day and lighting up large swaths of the sky at night. Then finally, billions of years from now, the Clouds will completely merge into the Milky Way and vanish.

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# The Voyager Casebook

**As it did for the Voyager encounter with Jupiter, Voyager 2 plays the backup role again, performing a close examination of selected targets at Saturn rather than a first-look and overview of the Saturn system. After a careful evaluation of the results from Voyager 1 and further months of hurried reprogramming of the camera and instrument sequences for the spacecraft computer, planetary astronomers have crossed their fingers in hope that Voyager 2 — the last American planetary effort until 1986 — will perform as well as her sister spacecraft did last November.**

**If all has gone well, the November issue of ASTRONOMY will carry a full report on the flyby of Saturn and the preliminary science results from the mission.**

## 82 Days before Closest Approach

On-board television cameras begin taking frames for two "movie" sequences. The first — an intensive record of four complete rotations of Saturn — provides a history of ring, planetary, and atmospheric features during this time. In the film, the planet spins at a leisurely pace through four rotations. The second movie is a zoom sequence running eight weeks. Voyager's cameras record the planet every two hours. The frames for five saturnian longitudes are assembled into a movie showing the planet — its rotation seemingly frozen — growing in the frame while low contrast atmospheric features drift across it.

Throughout the early phase of the mission, the craft's ultraviolet instrument scans the system looking for traces of a hydrogen gas torus in Titan's orbit. At the same time, radio instruments monitor the emissions of the planet.

## 26 Days before Encounter

When the image of Saturn and its rings no longer fits into the narrow-angle camera frame — about 25 million km from Saturn — Voyager enters the Far Encounter 1 Phase. The pace of the science activities begins to step up. Besides the ongoing observations of Saturn, the program for Voyager also specifies observations and photographs of the outer satellite Iapetus, an unusual object with one dark side and one bright side.

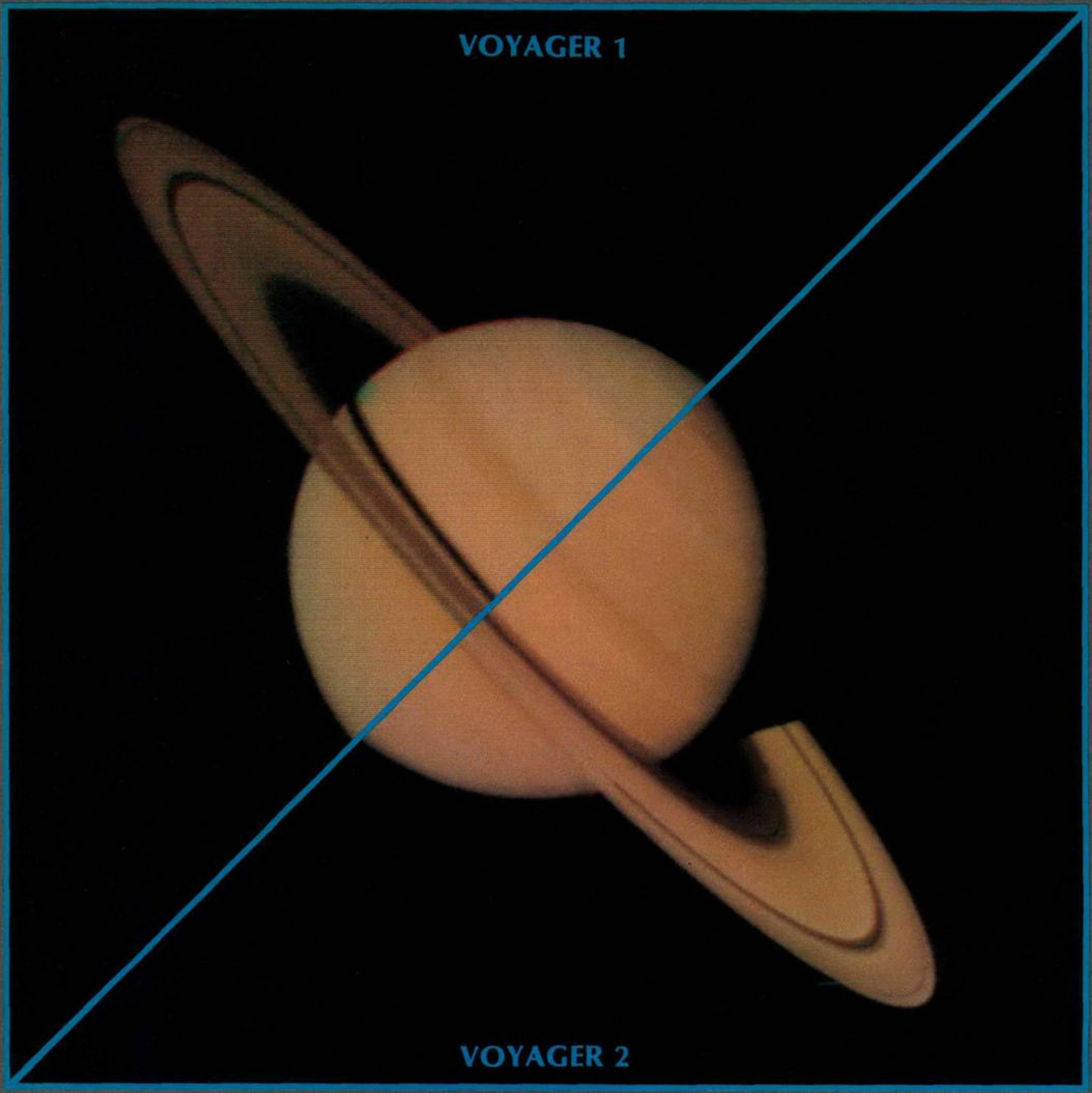
On this flyby scientists are looking at the ring system in more detail, and for a longer period of time, further exploring the enigmatic features found by Voyager 1. The F-ring — separated into strands that appear to be braided — are imaged repeatedly at high resolution. The eccentric rings are examined also because such "oddball" structures offer the best chance of discovering how the entire "normal" system works.

Of course, the dark radial "spokes" on the B ring are imaged. For Voyager 2, the rings are tipped at a steeper angle to sunlight than they were for the Voyager 1 encounter (when they were nearly edge-on), the observation period for the spokes is longer, and the viewing angles are better for recording motion and change. At the time of passage through the ring plane, Voyager's cameras search for evidence that the spokes are material raised above the ring plane by electrical discharges.

## 12 Million Kilometers from Saturn

Voyager enters its Far Encounter 2 Phase and begins a period of intensive observation of the spokes and B ring. Narrow-angle cameras record the B ring and its radial spokes every three minutes and create a detailed movie of their motion. Meanwhile, all the instruments are turned on and data about the planet and its satellites are streaming back to Earth. Late in this phase of the mission, Voyager crosses the orbit of Iapetus (imaging it four times more sharply than Voyager 1 did), Hyperion (from half as far as Voyager 1), and Titan.

Titan is the loser in the Voyager 2 flyby. Because Voyager 1 passed within 4,000 kilometers of Saturn's largest satellite and satisfactorily measured Titan's mass, magnetic field, and atmospheric composition while recording its featureless hazes at high resolution, the Voyager 2 mission planners decided to skip another close look at it in 1981 — instead they've charted a course for Uranus. Voyager 2 passes 150 times farther from Titan than did Voyager 1. Imaging of the rings replaces



**This composite picture of Saturn is made from images transmitted by the Voyager spacecraft. Note the difference in the brightness of the rings: they were nearly edge-on to the Sun during the Voyager 1 encounter, but are inclined 8° to the Sun for voyager 2's visit. Voyager 2 took its half of the image on June 28, 1981 from a distance of 56 million kilometers; Voyager 1 made the other from 76 million kilometers on September 17, 1980. The Voyager 2 image is NASA/JPL photograph number P-23782.**

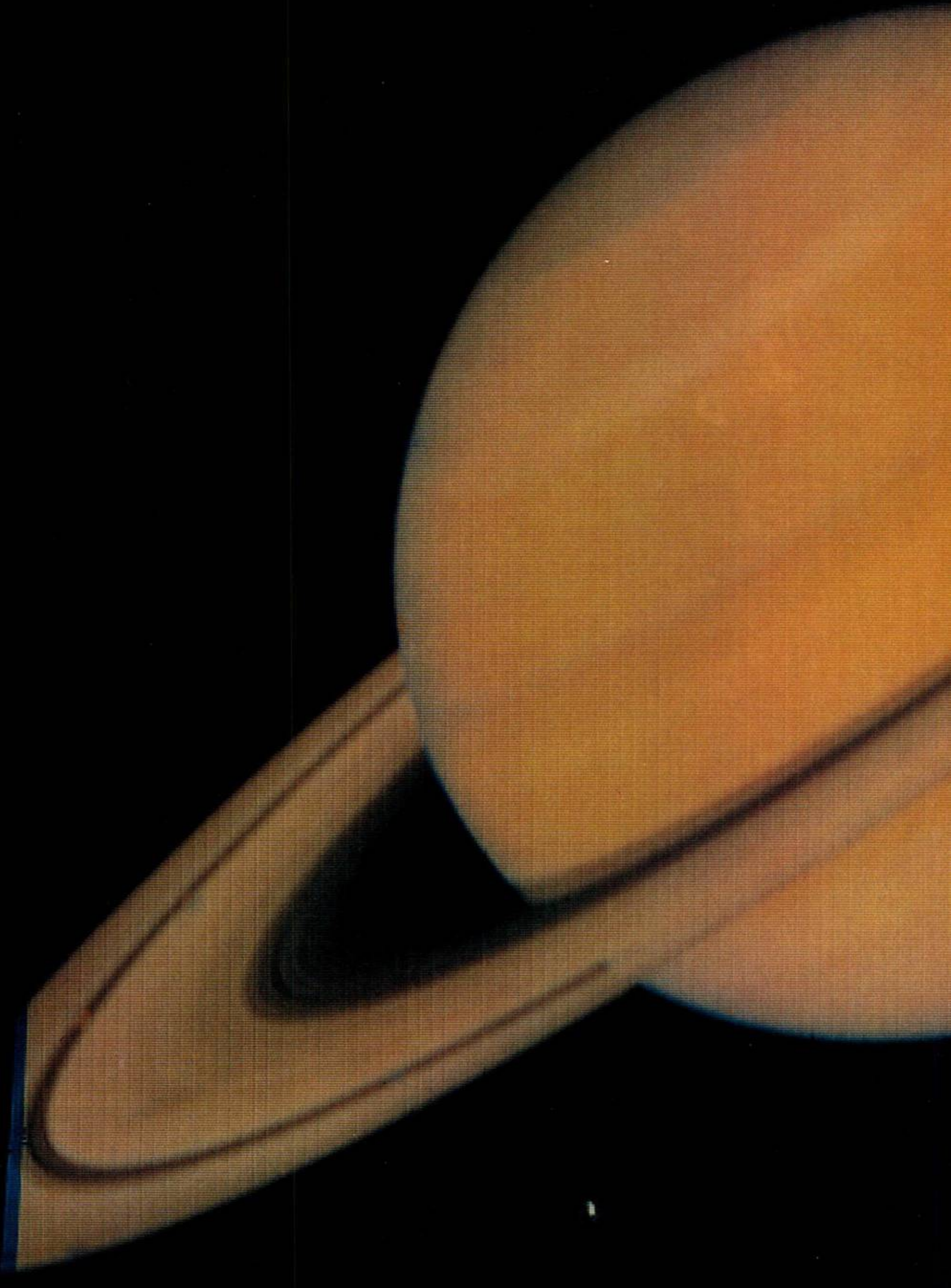
most of the time devoted to Titan on the Voyager 1 mission.

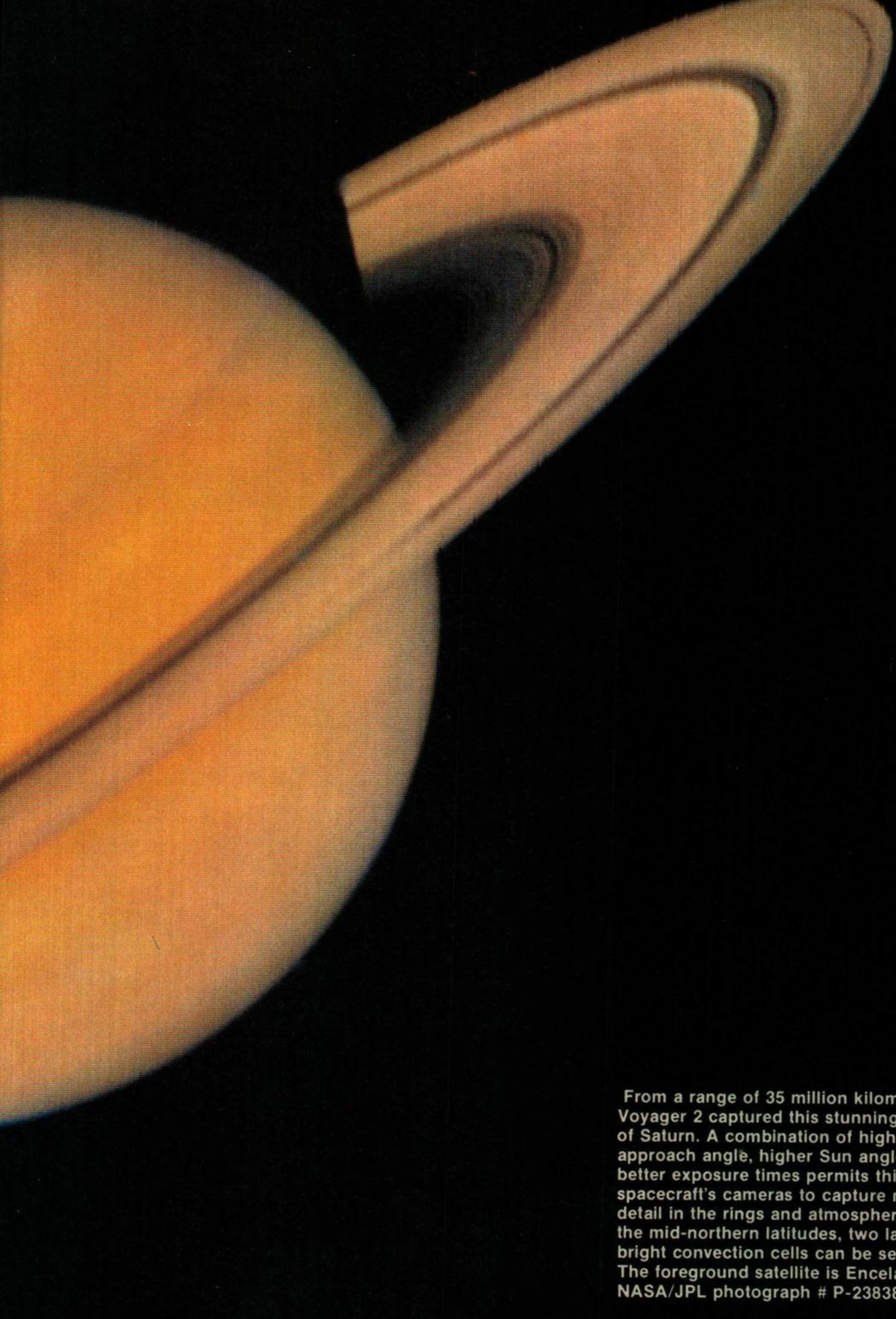
### 16 Hours before Closest Approach.

Near Encounter begins 43 hours of fervid activity as the ultraviolet and infrared sensors and the camera platform swivel from side to side, cramming in high resolution pictures of the Saturnian system: Dione from 502,000 km, Mimas from 310,000 km, Enceladus from about half the distance of Voyager 1, Tethys — the smooth-surfaced mystery moon — from five times closer than Voyager 1, and Rhea's cratered face from 640,000 km. Voyager 2's path through the system is carefully designed to complement Voyager 1's coverage by flying near the satellites that Voyager 1 saw only from a distance.

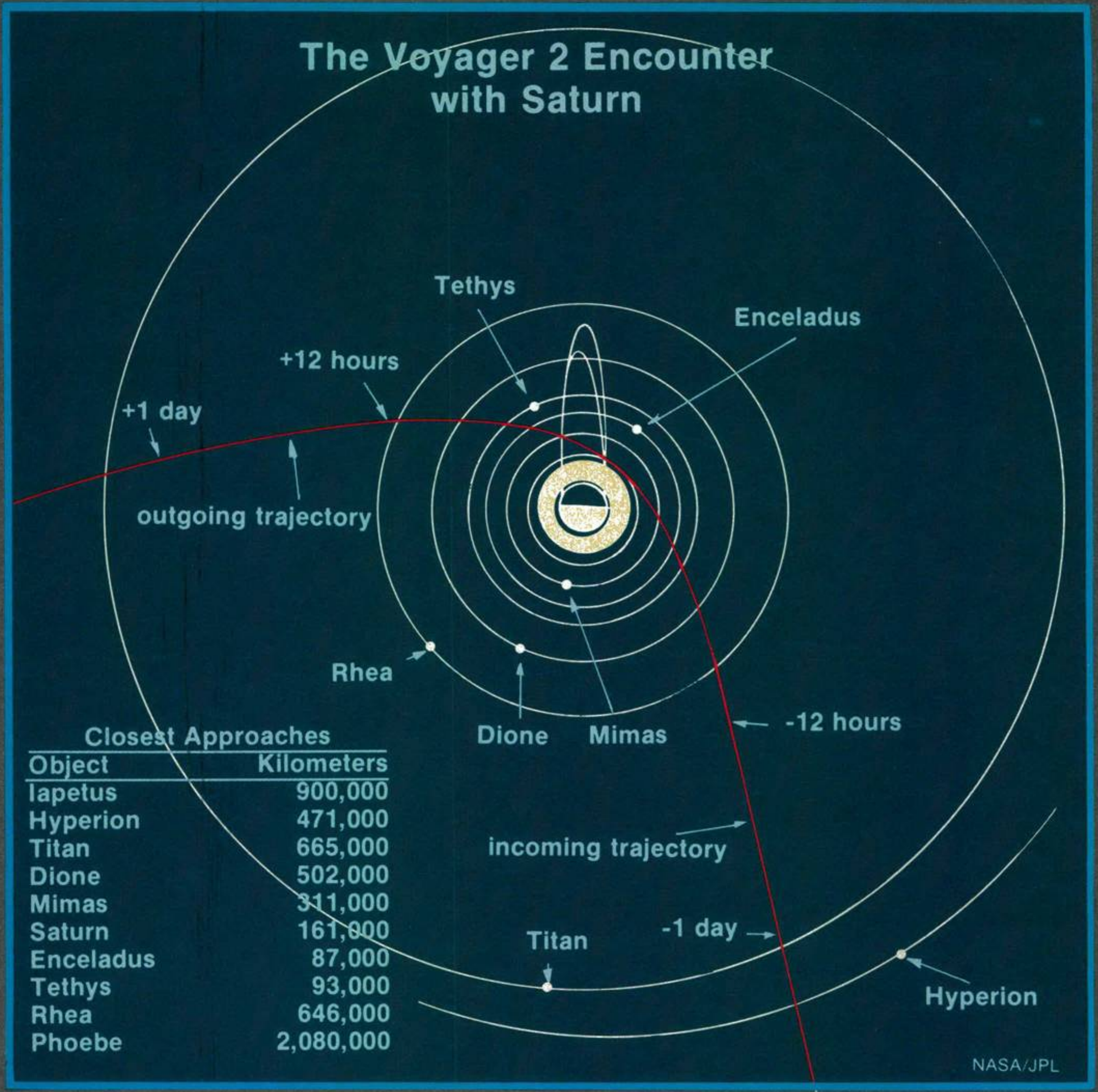
### Closest Approach

Voyager 2 passes from north of the ring plane to south of it yielding images better suited for detailed study of the rings. At closest, the spacecraft swings to within 55,000 km of the outer edge of the A ring: 112,000 km from the cloudtops and 161,000 km from the center of the planet. Because the G ring orbits at a distance of





From a range of 35 million kilometers, Voyager 2 captured this stunning image of Saturn. A combination of higher approach angle, higher Sun angle, and better exposure times permits this spacecraft's cameras to capture more detail in the rings and atmosphere. In the mid-northern latitudes, two large, bright convection cells can be seen. The foreground satellite is Enceladus. NASA/JPL photograph # P-23838.



The Voyager 2 Encounter with Saturn

Closest Approaches

| Object | Kilometers |
|---|---|
| Iapetus | 900,000 |
| Hyperion | 471,000 |
| Titan | 665,000 |
| Dione | 502,000 |
| Mimas | 311,000 |
| Saturn | 161,000 |
| Enceladus | 87,000 |
| Tethys | 93,000 |
| Rhea | 646,000 |
| Phoebe | 2,080,000 |

NASA/JPL

108,000 kilometers from Saturn, there is some concern for the safety of the spacecraft.

One important science investigation measures the ring structure using the star Delta Scorpii. Voyager's photopolarimeter, a light-measuring device, monitors the fluctuating brightness of the star's image and relays back to Earth the intensities it measures. This gives a high-resolution cross section of the rings and the ringlets within the rings. Scientists expect that details as small as half a kilometer can be resolved. Delta Scorpii was chosen because the section of the rings that it will be seen through lies in shadow, minimizing light interference from the rings.

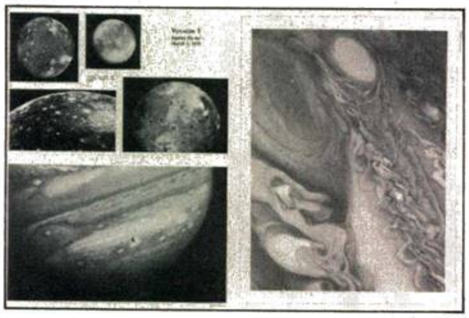
The fields and particles experiments aboard Voyager 2 penetrate deeper into the Saturn magnetosphere, since the spacecraft passes inside the orbit of Mimas — considerably closer than Voyager 1.

### Leaving the Saturnian System

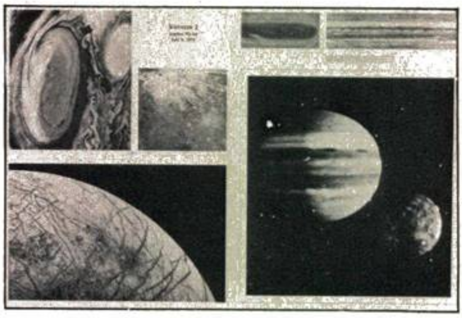
Voyager 2, leaving Saturn, passes six times closer to Phoebe than Voyager 1 did — although at a distance of 2 million kilometers little detail is expected. For 31 days the spacecraft continues its operations, measuring the fields and particles of near-Saturn space, and imaging the ringed planet. On the 32nd day, it fires its thrusters to adjust course for Uranus encounter in January 1986. Voyager 2 will be the first spacecraft from Earth to explore Uranus, its rings, and its satellites Ariel, Miranda, Oberon, Titania, and Umbriel.

*— Richard Berry*

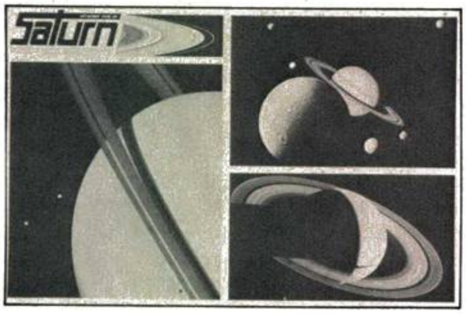
# Complete Your Fly-By Poster collection with Saturn 2



**JUPITER 1.** Images from Voyager 1 of the Red Spot, floating satellites against the planet and close-ups of the fabulous Galilean moons.



**JUPITER 2.** 6 more unduplicated photos of the miniature solar system from Voyager 2. A perfect complement to the Voyager posert at left.



**SATURN 1.** The jewel of the solar system reveals its hundreds of rings, radial spokes and curious collection of satellites.

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**SATURN 2.** Due to this issue's deadlines, photos from Voyager 2 at Saturn are not available for publication.

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# Voyager Fly-By Poster Series

# ASTRONOMY FORUM

## Parallel Universes: A Tale of Two SETIs

Recently, two conferences near San Francisco examined the question of extraterrestrial life. NASA sponsored one of the meetings at the Ames Research Center, at Moffett Field, analyzing prospects for "Life in the Universe." Two weeks later at the Airport Marina Hotel, the Mutual UFO Network conferred on "Intensifying the Scientific Investigation of the UFO Surveillance."

Only a few social scientists were at either meeting, and, as far as I know, I was the only person — scientist or layman — present at both. Between all the people attending the two meetings, there appeared to be no overlap. It was as if two parallel universes existed side by side, with neither aware of the other. What is the reason for a near-total separation between two groups which seem at first glance to be interested in the same "far out" subjects?

There were enough similarities between the two meetings. Both followed the same format, with an organized presentation of reports from a schedule prepared in advance and listed in a printed program. Both lasted two days and had about 30 speakers. Both were national in scope, drawing speakers and audiences from as far as New York and Hawaii. And each one was the latest in a series extending back a number of years: it was MUFON's 10th annual meeting, and NASA had sponsored at least half a dozen previous symposia on SETI (Searching for Extraterrestrial Intelligence), plus two or three on related topics like extra-solar planetary detection.

The elder statesman of each field is a physical scientist, and each addressed his respective meeting calling for new approaches to the challenges confronting their groups. At the MUFON meeting this scientist was J. Allen Hynek, astronomer emeritus of Northwestern Univesrsity, while MIT physicist Philip Morrison was similarly prominent at NASA's SETI conference. Both men had given impetus to their fields over twenty years ago, when they noted possible sources of highly significant data. Hynek, as the scientific consultant for the Air Force's Project Bluebook, had found some UFO reports which could not be satisfactorily explained. Morrison had suggested that radio waves of 21 centimeters wavelength might be used by other civilizations to beam communications.

Neither group has conclusive evidence that would convince a skeptic or nonbeliever that the phenomenon actually exists.

Despite these similarities there were differences betwen the two groups. The SETI conference was by invitation only and was attended by two hundred scientists. The MUFON conference was open to the public, attendance was several times larger, and the audience consisted largely of people without Ph.D.s.

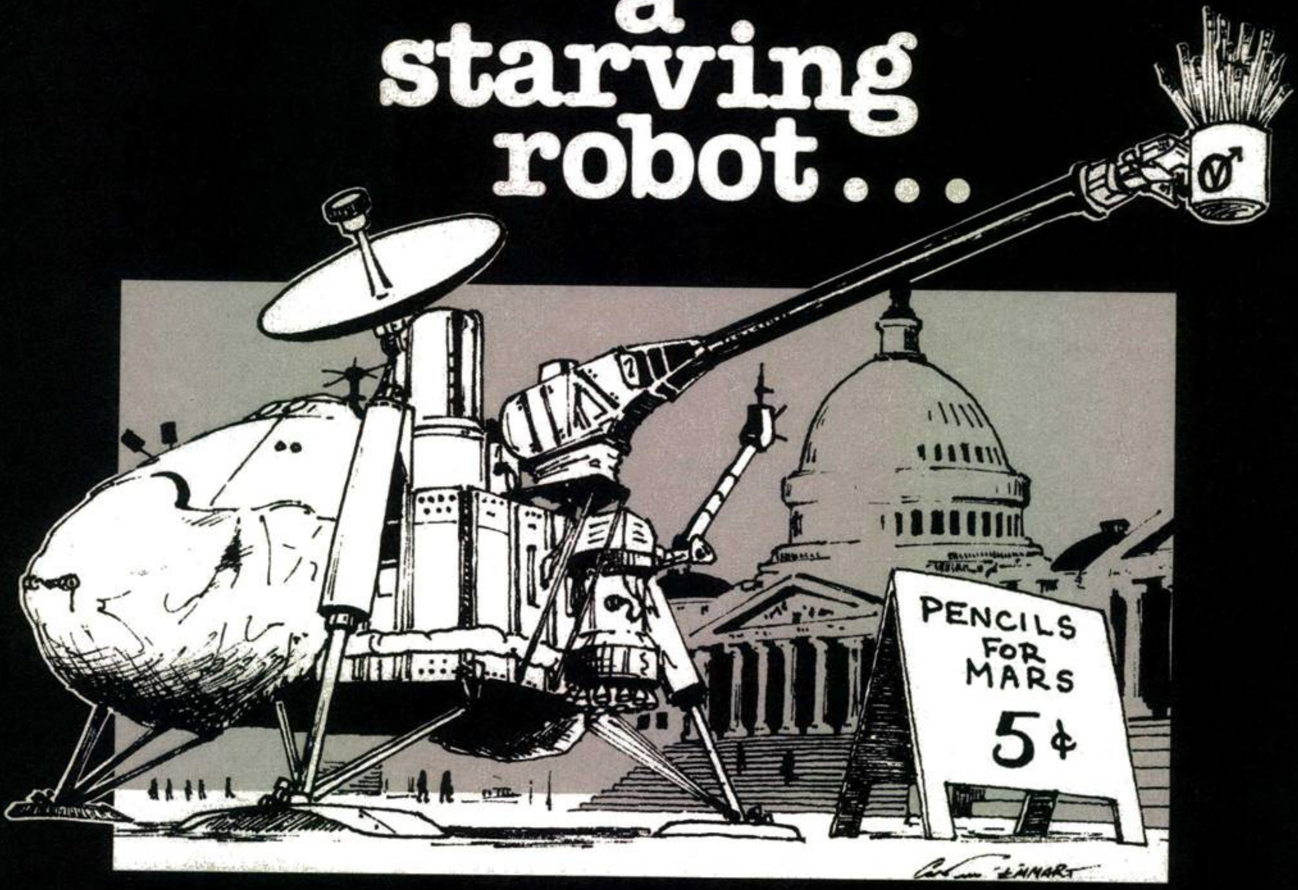
Although laymen were not invited to the SETI conference, scientists could have attended the UFO meeting if they had wanted to. There are several reasons why they did not; before discussing them, it may be helpful to examine the contrasts in more detail.

While it is often assumed that UFOs and ETI are the same or similar, there are important differences. UFOs supposedly are here, on or near Earth, while ETI as currently envisioned is very far away — tens of light-years or hundreds of trillions of miles beyond our Solar System. In addition, UFOlogists are primarily concerned with specific events occurring now. While SETIsts, too, are concerned with the present — detecting electromagnetic signals arriving from other planets — the desire to find likely sectors of the sky in which to seek such signals encourages them to consider a broad range of phenomena associated with planetary formation and evolution of intelligent life.

The methodology of the two groups is very different. The SETIsts' is basically simple: use radio telescopes to seek and send signals. Though additional sophisticated equipment could be employed, it exists now within its present technological capabilities.

UFOlogists, conversely, have not developed a straightforward plan for analyzing their elusive quarry. What seemed 30 years ago to be a relatively simple phenomenon now appears more complex. Metallic saucers or cigars suggestive of interplanetary spacecraft are only one manifestation of the phenomenon as currently perceived by UFOlogists. Changes in shape, size and color, along with purported paranormal effects, have

# Feed a starving robot...



## ...and a starving space program.

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undermined the tenability of the "simple" spacecraft hypothesis. Consequently there are at least eight theories about UFOs, but no satisfactory plan for studying them.

SETI and UFOlogy also differ with respect to their data. Although neither field has the hard evidence of what they believe to exist, there are literally tens of thousands of UFO reports, some by presumably credible observers, including astronomers, aviators, meteorologists, air traffic controllers, police — and even a former president, Jimmy Carter. In contrast, there have been no verified claims for detection of ETI. *Science* magazine (Feb. 3, 1978, p. 485) reported that at least 10 organized searches for ETI — some with the largest radio telescopes — have been conducted, but the results have all been negative.

**UFOlogists see little chance of federal funding in the immediate future, or even on the horizon. Therefore their only hope is to develop popular support through public meetings, television interviews, and so forth.**

The logic of the two groups is also contrasting. SETIsts use deduction while UFOlogists employ induction. SETIsts start with the hypothesis that intelligent life exists elsewhere in the universe, and look for extraterrestrial radio signals as evidence to support their hypothesis. Conversely, UFOlogists start with reports of strange phenomena and seek a theory to explain them.

In a sense, SETIsts also employ inductive methods in that they generalize from the observation of one case: life on Earth. From this single case, they go on to assume that life also exists elsewhere. By the same token, some UFOlogists say that intelligent life probably exists elsewhere and perhaps has developed technically to a degree that it can send space vehicles to visit us here. Nevertheless, while both groups use some elements of both processes, the primary emphases of the two groups are in the opposite directions.

Thus the two fields have differing blends of theory, method and data. SETIsts have a theory (intelligent life has evolved elsewhere in the universe) and a method and equipment for seeking it (radio telescopes with computer analyzers), but lack evidence for ETI. In contrast, UFOlogists have plenty of evidence, at least "soft" data, but no single satisfactory hypothesis and no simple plan of investigation.

These contrasts were evident in the topics presented at the two conferences. The SETIst concern with finding likely locations for intelligent life, and specific means of communicating with it by radio, were indicated by papers with these and similar titles: "Climatological Stability," "Biochemical Keys to the Emergence of Complex Life," "Detecting Planets in Binary Systems with Single Aperture Interferometers."

MUFON, exploring the implications of UFO reports, presented a workshop with UFO witnesses, a film of a New Zealand sighting, and lectures on such topics as "Parallels with Other Altered Consciousness States," "The Religious Dimension to the UFO Phenomenon," and "Analysis of Sound Impulses Recorded During a Period of UFO Activity in Bugg Creek, Alberta."

The two groups also differed on the possibility of connections between UFOs and ETI. UFOlogists discussed this issue but SETIsts did not. UFOlogists, in fact, are quite interested in propulsion systems and the chances that probes from other planets may be visiting us. One of the major addresses at the MUFON meeting examined the "Case for the Extraterrestrial Origin of Flying Saucers," and another report dealt with UFO propulsion systems which, the speaker suggested, might make interstellar travel possible.

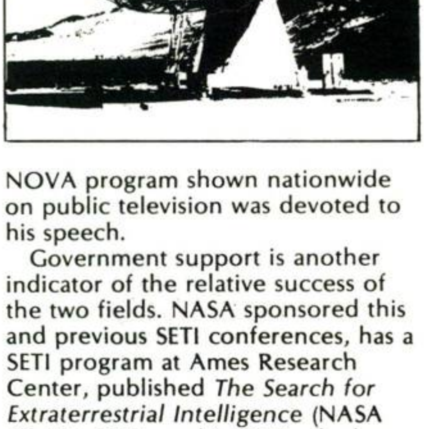
Both groups seek friends and funds, but take opposite approaches to publicity. UFOlogists see little chance of federal funding in the immediate future, or even on the horizon. Therefore their only hope is to develop popular support through public meetings, television interviews, and so forth. The cover of the MUFON symposium program displayed the prominent caption; "Stressing Public Education of the UFO Phenomenon."

In contrast, SETIsts work quietly to build a theoretical framework and to enlist the support of other scientists. Believing that federal research money is almost within grasp, SETIsts feel that the public spotlight would hinder their cause, not help it. However, SETIsts have been considerably more successful than UFOlogists in gaining the support of scientists and the government. To put it another way, in the study of unconventional celestial phenomena, SETIsts are the "haves" and UFOlogists are the "have-nots."

Most of the speakers and audience at the SETI conference were professional scholars and scientists; most at the MUFON meeting were not. Moreover, every speaker on the ETI Program was affiliated with a well-known university or research institute: Harvard, MIT, University of California, National Center for Atmospheric Research, Scripps Institute of Oceanography, and Jet Propulsion Laboratory. Although there were eight Ph.D.s on the MUFON program, their affiliations were not as prestigious.

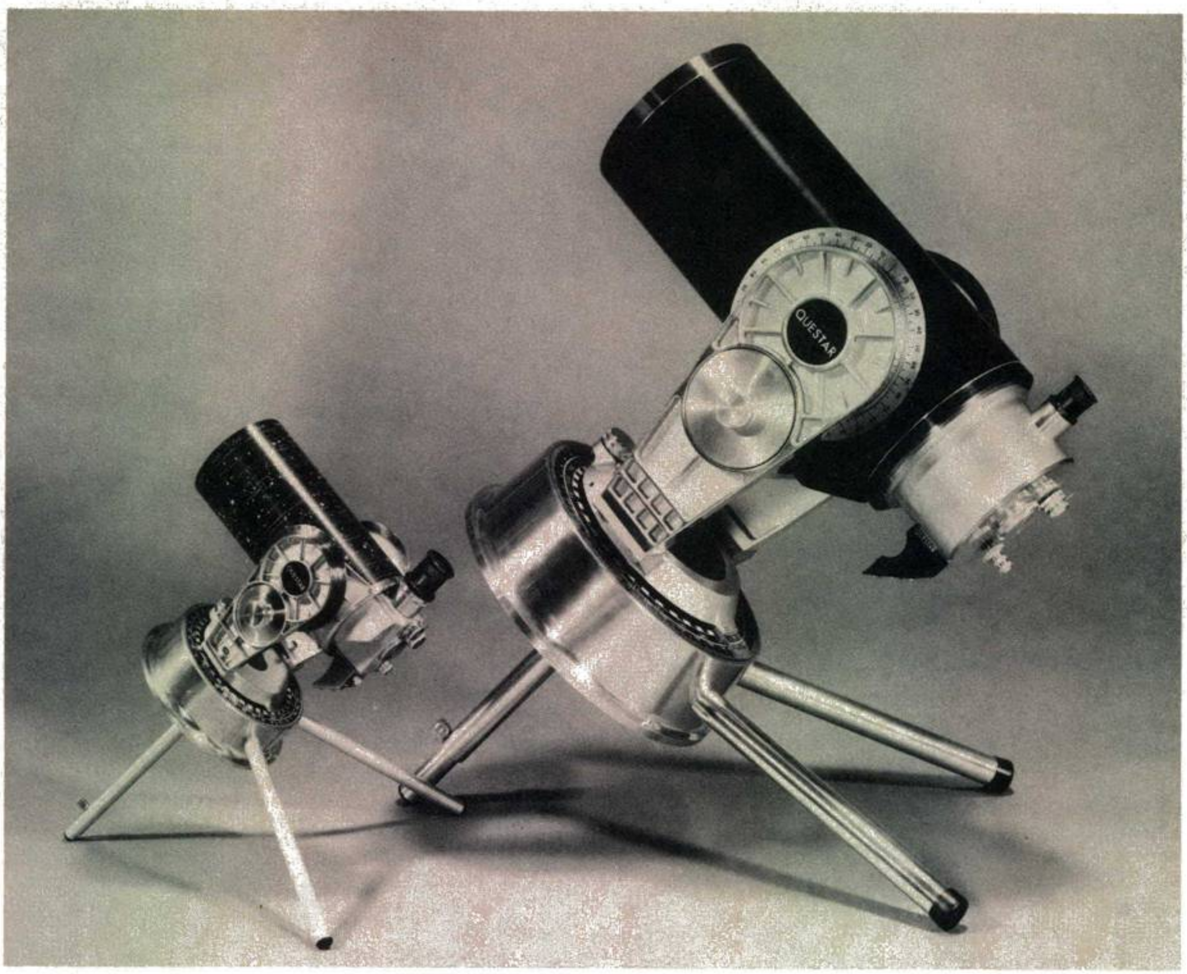
Were these two meetings really representative of the two groups? Yes — if anything these meetings minimized the usual differences. The MUFON program had a higher percentage of PH.D.s than are generally involved in UFOlogy, while previous NASA SETI conferences have included Nobel laureates Joshua Lederberg, who investigated the organization of genetic material in bacteria, and Charles Townes, who developed the laser and maser.

A status difference also exists between the elder statesmen of the two fields. While UFOlogist Hynek is considered a capable scientist from a respectable university (Northwestern), Morrison of M.I.T. has greater prestige. Among other prestige indications, he was chosen to give the Jacob Bronowski memorial lecture, and an entire NOVA program shown nationwide on public television was devoted to his speech.



Government support is another indicator of the relative success of the two fields. NASA sponsored this and previous SETI conferences, has a SETI program at Ames Research Center, published *The Search for Extraterrestrial Intelligence* (NASA SP-419, 1977), and in 1978 asked Congress for two million dollars for SETI.

In contrast, the government's



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The Seven also has the famous Questar system of built-in conveniences: low-power finder, high-power changes without changing eyepieces, star diagonal prism, synchronous electric drive, setting circles, worm-driven sidereal clock, and continuous 360° smooth slow motions. All are included in the price of the telescope, and included too are the Questar totally safe solar filter and basic camera coupling set.

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The remarkable Questar drive impresses everyone who uses it. Hubert Entrop, who takes beautiful deep-sky photographs (a number of which we have published here and in our recent issue of QUESTAR OBSERVATIONS), frequently comments on the quality of the drive. He has written us: "The motor drive on the Seven works very smoothly and quite precisely, even though the guiding is being done at twice the focal length of the 3½."

Another time, when sending us some pictures, he said, "The Seven base drive is so smooth that the shutter in the off-axis guider was not used even once for all four of these exposures." And again, "With the Seven there is never any problem in guiding; it no doubt has the best motor drive of any scope outside of observatory equipment."

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attitude toward UFOs has been negative. NASA hasn't sponsored any conferences on UFOs, and rejected Jimmy Carter's request to investigate them. A NASA administrator stated that UFOs are not a matter for serious scientific discussion, and the same conclusion was reached by the Air Force sponsored Condon Report conducted at the University of Colorado in the 1960s.

Why this difference? Why are scientists inclined to support SETI and avoid UFOs? There are several reasons. First, it is easier to deal with radio signals than with little green men and people who claim to have seen them. Radio signals can be listed on a computer printout and analyzed by established research techniques. Most UFO reports lack scientific rigor. The underlying concern is control, a crucial element in scientific research. SETI, as envisoned by radio astronomers, would give them control over their research. Special equipment would be required to detect a signal from outer space, and even then, deliberate efforts would be necessary to find it among all the other radiation picked up by the sensitive equipment. The scientists could define what constitutes acceptable data, gather it under conditions they themselves determined, and analyze and evaluate it as they saw fit.

In contrast, UFOs are not easily controlled. They may appear anywhere, anytime. They are visible to the unaided eye, and are reported by all kinds of people. The reports might, or might not, be truthful.

SETI is also compatible with present theories and methods. No basically new techniques need be invented and no new cadres of specialists will be required. Receipt of radio signals from an extraterrestrial civilization would not necessarily overthrow established concepts about the universe and how it works. Today's scientists could use the same kind of equipment to do the same kind of work they do now as they search for ETI.

Furthermore, SETI has had less of the ridicule, sensationalism and unfavorable publicity which afflict UFOs. Even Senator Proxmire's Golden Fleece Award to NASA created less stir than a routine UFO flap would have aroused. Lack of sensationalism allows scientists to look for ETI at their own pace, under conditions chosen by them rather than by public pressure. In order to keep the situation this way, NASA and scientists interested in SETI are maintaining a low profile while they seek federal funding.

Even though SETI has the support of NASA and an impressive array of scientists, its financial position is insecure. In 1978 Congress rejected NASA's appeal for SETI funds, allocating not a single cent to it. Despite this setback, SETI is on the verge of being accepted as a respectable, even fashionable, scientific endeavor. Yet the proximity of success leads SETIsts to be cautious. Having only recently risen above the tawdry realm of comic strips and science fiction, SETI is concerned with presenting a dignified image. SETIsts do not want their image tarnished by any connection with the "lunatic fringe."

UFOlogy is thus not an ally but a threat. UFOs represent a potential source of embarrassment for SETI.

**Believing that federal research money is almost within grasp, SETIsts feel that the public spotlight would hinder their cause, not help it.**

The situation is reminiscent of the familiar fear held by many upwardly mobile people that their recently acquired respectability will be jeopardized by association with less sophisticated relatives and former friends. SETIsts feel they have nothing to gain from UFOlogists, and much to lose.

This then is another reason, along with tremendous interstellar distances, why the SETI conference did not examine the possibility that ETI may be any closer than the distant stars, and particularly that ETI may be visiting us here and now. By keeping ETI far away, its seekers may avoid undue public attention which might attract the lunatic fringe.

SETIsts downplay anything which might suggest a link between ETI and UFOs. SETIsts seldom discuss UFOs, and, when they do, emphasis is placed upon the virtual impossibility of interstellar travel due to the vast distance and the tremendous times needed to traverse them. SETIsts feel the safest assumption is the ET beings are similar to us, and that physical laws as we now understand them are applicable throughout the universe.

UFOlogists, on the other hand, are not as committed to established scientific theories. They are, in fact, inclined to think these may be wrong or, at the very least, inadequate — and that interstellar travel is indeed somehow possible. For people who believe UFOs are real, the extraterrestrial hypothesis is the most popular, though not the only one. Parallel universes, time travel and psychotronic manipulation are among the alternative explanations.

Thus, what appeared at first glance to be parallel approaches to ETI actually differ in important respects. At least in part, the differences can be explained by the contrasting positions of their advocates with respect to mainstream science and federal funding. For established scientists, SETI could provide a long term project which could begin immediately, use present personnel and equipment, and be guided by scientists. Then if the effort was successful in finding signals from another planet, its findings would stand a chance of fitting into our present concepts about life and the universe. SETI, despite its exotic trappings, is actually a moderate, middle-of-the-road scientific activity. It does not imply, at least as it is now envisioned, a confrontation with today's science or scientists.

UFOs are more troublesome. Starting from data that is soft and comes from outside established scientific frameworks, their ultimate implications are unpredictable. UFOs seem to violate basic laws of physics. If the claims made about them turned out to be correct, present assumptions about time, space and matter might have to be radically altered. While most scientists are open to refinements of existing theories, they would be less enthusiastic about abandoning these concepts completely, particularly if the case were to depend on messy data reported by laymen. Thus, most scientists, if they are interested in unconventional topics at all, would prefer to search for ETI rather than for UFOs.

*David W. Swift*
Department of Sociology
University of Hawaii
Honolulu, HI

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## Shuttle: Another Giant Step or a Military Tool?

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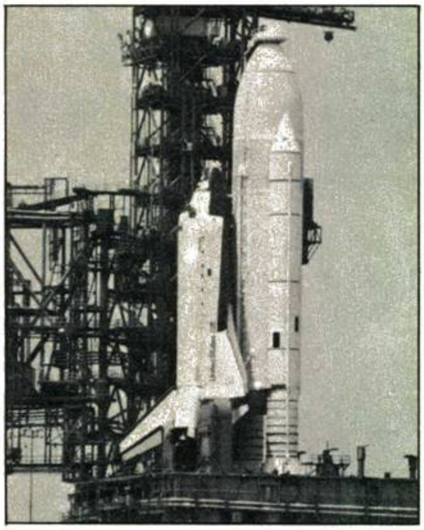

**But the Shuttle has been condemned by some as the first step in escalating the arms race into space. And nobody in America seems to be denying it.**

But the Shuttle has been condemned by some as the first step in escalating the arms race into space. And nobody in America seems to be denying it. It's hard to imagine that only six years ago Apollo astronauts linked with Soyuz cosmonauts for the first international handshake in space.

Today, U.S. military analysts believe that our reusable spacecraft offers us national superiority. Shuttles could be used to assemble military outpost satellites equipped with lasers and other sophisticated weaponry — in other words, battle stations in space.

But even before we've taken the first step toward such a futuristic base in space, Russia is boasting of a successful anti-satellite weapon. Will this tempt us to do the same? Might the Shuttle be doomed to this scenario? Projects like the launching of a deep-space telescope are much more imaginative than Spy vs. Spy in the sky.

Consider again the Space Telescope: an unmanned multipurpose optical telescope observatory. It could be launched as early as 1985. It will provide all mankind with a new perspective on the neighboring planets, continuously transmitting information about their physical conditions and atmospheres. The 94-inch mirror, launched and maintained by shuttles, could extend our view into the depths of the cosmos some fifty times. Perhaps it could even give us a glimpse of the birth of the first galaxies.

Which will it be? If we devote ourselves to the development of laser weaponry, we condemn ouselves to a future of "star wars." Can we not gear our efforts to more productive tasks? With imagination — the propulsion fuel of mankind — we can dream up images of solar sailing, orbiting farmlands, and interplanetary travel, and make them realities. It's all within our grasp in the age of the Space Shuttle.

*Kenneth McCaleb*
New York

## New Ideas For An Old Planetarium

Like many amateur astronomers, I am fascinated with good planetarium theater. But too many planetarium programs, I feel, are unnecessarily dull. And I'm not alone in that opinion. On a recent TV comedy show, "WKRP in Cincinnati," the writers showed just how boring a character named Les Nessman is by having him take his date to the planetarium!

The quintessential dull date, these writers seemed to be saying, was your local star theater. Judging from the laugh the joke got, the live studio audience seemed to agree.

I have always had a lot of ideas for improving planetarium programs, which I have freely given to planetarium directors — and which they have just as freely discarded. While I would have enjoyed the opportunity to direct a planetarium myself, I never expected to get the chance since my degree is not in astronomy. Then one day the unimaginable happened — I was named director of a small college planetarium. After years of offering unsolicited advice, I was suddenly in the interesting position to test my theories.

As I looked about the 50-seat star theater that was now mine, I wondered what I'd gotten myself into. The planetarium projector was an old Spitz A-3-P which hadn't had any factory maintenance since it had been purchased. Even worse, with *Star Wars* then due at our local theaters, I found that my star theater didn't have any special effects projectors — nor did I have any transparencies!

All I had was a star projector and a few ideas. And just what were these great ideas? Well, for this particular planetarium they were:

1. No taped shows. People already get enough canned entertainment from TV and films. In fact, since this was a one-person planetarium, I eventually found it was best not to have scripts. Scripts must be read — and they always sound as if they are being read.
2. Present subjects the public is interested in, not necessarily those subjects the director is most interested in.
3. Use special effects and sound effects.
4. Cover broad topics rather than narrow topics.
5. Present the wonder of astronomy. It's an exciting subject. A person has to go out of his way to make it dull.

Things started off well enough. In addition to presenting school shows three days a week, I was contracted to give free public shows one weekend a month. The theater filled for the public shows.

Then Proposition 13 passed in California, and the college began to charge $1 for the public shows. I was apprehensive about going from free to paid shows, but attendance remained high and even began to increase. In fact, attendance increased so much that we had to open two weekends a month. The college responded by raising the price to $1.50 — to keep people away. Still attendance increased.

We added folding chairs to bring the seating up to 60 and we sold standing room, but we couldn't get all the people in. So we went to being open every weekend of the month.

**After years of offering unsolicited advice, I was suddenly in the interesting position to test my theories.**

Attendance continued to increase but now there were no more nights we could be open, so we were forced to start doing two back-to-back shows a night. We still have problems with crowding and long waiting lines as I write this, but the

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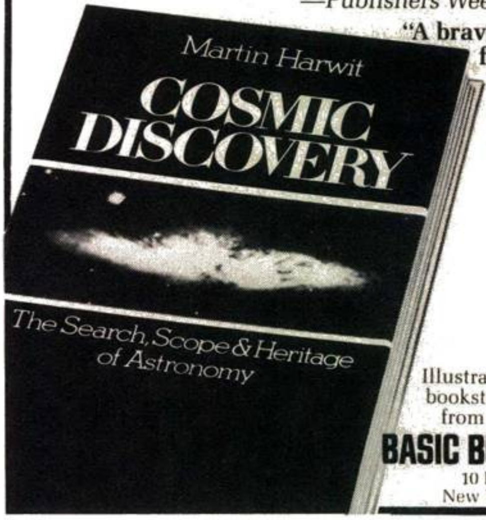

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HERE'S THE COMPLETE REVIEW FROM THE AUGUST ISSUE OF **ASTRONOMY**

**Plössl Eyepiece Set**
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"An eyepiece is an eyepiece — why spend any more than you have to on them?" said a friend of mine when I mentioned I had just purchased a set of Tele-Vue eyepieces. Certainly at $55 each, the price is enough to make anyone stop and think twice. But I am satisfied because the Tele-Vue Plössls are the sharpest I've ever used.

For years I've gotten along with a pretty ratty set of eyepieces, some that I bought 20 years ago, some that came with various telescopes, and a big Erfle I bought a few years ago. I've looked at, and been tempted by, newer ones, but whenever I've compared them at ATM meetings, I haven't seen any that gave sharper images than those I already own.

The Plössls arrived looking beautiful. Nothing was loose; nothing rattled or shook. They were extremely clean and dust-free. For a quick check, I tried all four in my Astroscan — then I knew I had something good! Even with the f/4.5 optical system of the Astroscan, the images were crisp and sharp nearly to the edges of the field. When I focused, the image seemed to "snap" at the moment of best focus instead of mushing through focus as do many eyepieces used on a fast optical system.

I frequently use the Astroscan for projecting the solar image. My trusty old 28mm Kellner eyepiece does a terrible job — the image is mushy and has color fringes. The 28mm RKE is a vast improvement — but it still is a bit soft through focus and some detail is lost. The 26mm Plössl does a superb job — tiny low-contrast details in sunspot penumbrae stand out sharply.

Used with my 12" f/7 telescope, the Plössls deliver crisp images of the planets. I have the distinct impression that the eyepiece adds no optical errors to the image I'm viewing, and that I am seeing everything the mirror can deliver. This is an impression I've never had with any other eyepiece.

Tele-Vue's Plössls also look handsome. They are quite heavy, feel solid, and possess details of fine workmanship. Their shape fits my eye quite comfortably. Although the 26mm can be used with glasses on, I must remove mine to use the others. Without glasses on, I must refocus slightly when I switch from one eyepiece to another. One slight note of caution: the barrels of these eyepieces are *exactly* 1.250" in diameter. Since one focuser I own is undersize by several thousandths of an inch, the Plössls do not fit it properly. If you buy these eyepieces, you may also have to upgrade your focuser.

Are these eyepieces worth their price? If you are using a slow optical system, most eyepieces will give you a satisfactory image. With fast optics, however, I haven't seen anything to match them.

*Richard Berry.*

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college is preparing to try advanced ticket sales and has raised the price again — to $2.50.

I'm sure a lot of this has to do with Carl Sagan and science fiction movies and a public which is becoming more aware of astronomy. But our 800% increase in attendance may also indicate that we're doing something right. A much better-equipped planetarium in the next county refuses to give shows if less than six people show up. We never have that problem. We have problems trying to decide whether it's fair to charge people who are going to have to sit on the floor.

As I gained experience I learned that each audience is different, so each show ideally should be different. Some audiences are thoughtful; others want to laugh. Some audiences want a short show; others would like you go on all night. So, while each monthly show has the same theme, we improvise on that theme. The show can run anywhere from 30 to 90 minutes, with most shows lasting an hour or so. This is why I no longer use scripts. And the only thing on tape is music and sound effects. Today I can tell within five minutes of starting what kind of audience I have and what kind of show I should give.

Special effects: at first we had no budget for them, so the special effects had to be made out of garbage — literally. I would search the garbage bins behind discount drugstores. One of my best special effects is an aurora borealis made from an electric cigarette lighter display case. A fellow from Norway came up after one show and told me the "northern lights" reminded him of home.

Broad topics: just the titles of the most popular shows suggest topics audiences want: "Going Home to Mars," "The Jupiter Effect and Other Ways the World Will End," "The Mystery of Sirius B," "The Rich Winter Sky," and "UFOs: Fact, Fantasy, or Religion." Surprisingly, the most popular of all was a show called "Einstein at 100," which we now repeat every year. It has grown to a two-hour show, and during the first hour I don't use the planetarium projector at all.

The show came about when I noticed that Einstein programs for the general public make no attempt to explain relativity; they just try to show what relativity does. I wanted to try a plain-language explanation of some of the seemingly odd things which happen within Einsteinian physics. Giving an Einstein show is nerve-wracking because occasionally I will spot a physics or astronomy instructor in the audience. But so far these instructors have been kind with their comments. Our current shows are: "Did We Really Land on the Moon" and "New Wonders of the Universe."

Along the way I learned: The planetarium director, especially in the beginning, must take responsibility for publicity. Even if the director is associated with an organization which has a public information officer, the PIO may be busy with other things. Once the planetarium gets going, audiences will return on their own each month and create word-of-mouth publicity.

In fact, you may even reach the happy stage where newspaper, radio, and TV reporters come out to ask you why the planetarium is doing so well, or ask you to comment on something in the news that day about astronomy.

It will also be the director's responsibility to keep equipment repaired. Even if you are associated with an organization which has repair people, they may not have time for you or know how to deal with planetarium equipment. In those situations, repairs are better made by the director and his friends — or maybe an occasional college vice president.

When I was a typically obnoxious 15-year-old kid hanging around the Morrison Planetarium in San Francisco, there was a very tolerant director there named George Bunton who allowed me to argue with him about the major planetarium question: Is a planetarium show education or entertainment? The easy answer is that it is both. But nothing in life is that easy, and frequently we must go one way or the other. (Incidently, to repay Dr. Bunton's kindness, I am always very tolerant of obnoxious 15-year-olds.)

Forced to choose, I would come down on the side of entertainment. While all planetarium programs are educational to one extent or another, I feel strongly that if I can entertain people and bring them back over and over again, I will teach them more astronomy in the long run than if I try to teach them.

I suspect, also, that most people come to planetariums more for entertainment than to be taught a lesson. One Japanese woman wrote to say some kind things about our programs, and added this: "Japanese [planetarium] shows are boring, like a grammar school science book." Most people simply do not remember school days fondly, so a planetarium program should be as different from a school lesson as possible.

Though at first I had misgivings about working a one-person planetarium, I have since discovered some real advantages to it. Because I must do everything myself, things get done the way I want them done. This calls for working extra hours, but I think of the planetarium as my hobby as well as my job. It takes extra creative energy to plan a flexible, scriptless show each month, but it allows the director of a one-person planetarium to be on a very intimate level with the audiences.

**Is a planetarium show education or entertainment? The easy answer is that it is both. But nothing in life is that easy, and frequently we must go one way or the other.**

What I hope my own experience proves is that it is not essential for a planetarium director to have an astronomy degree. Many life-long amateur astronomers have more knowledge and imagination than I do, and they could do a fine job if someone gave them a chance. But I can tell such people right now that it's not easy to get that chance.

Finally, if someone were just starting out in a small, one-person planetarium and asked for some quick advice, I would offer this: Today's planetarium audience prefers to have a live person talking to them, not "at" them or "down to" them, but directly to them.

*Allen Grasso*
Cabrillo College
Aptos, CA

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eye
on the
sky

# venus shines low in the evening sky

by
Fred Schaaf

## the wanderers

The three planets and several bright stars which faded into the Sun's afterglow last month are invisible until late October, when they will pop into view in the morning sky, hastened up by the steep angle of the ecliptic in the east at this time of year. Meanwhile, during the entire month, **Venus** is prominent in the evening sky as it skims very close to the bright stars of *Scorpius.*

Venus gains a few more degrees of altitude in the west this month, but is still not very well placed for North American viewers because of its extreme southerly position on the sky. Although its greatest elongation from the Sun occurs next month, Venus is now entering the southernmost constellations of the zodiac and is also farthest south of the ecliptic on October 29. It will not be at its highest for us in the after-sunset sky until mid-December. Venus sets only about two hours after the Sun during October; its spectacular brightness increases slightly from -3.7 to -3.9 magnitude.

The conjunctions involving Venus this month are dramatic. On the 11th, it passes through the head of Scorpius and is only about a half degree south of second magnitude Delta ($\delta$) Scorpii, also known as Dschubba.

Viewers with small telescopes can glimpse Venus as it passes the globular cluster M-80 and approaches 4.8 magnitude 19 Scorpii on the 14th and 15th. But the planet's finest conjunction occurs on the 17th, when Venus is located less than two degrees north of one of the heavens' brightest stars, first magnitude Antares. While you compare the yellow-white gleam of Venus with the ruddy hue of the star, remember that this pairing is unusual because Antares lies a good way south of the ecliptic and planets seldom approach it so closely.

In 1984, both Mercury and Mars will get almost as near to the star, but not until 1989 will any planet get closer. Again it will be Venus, which every eight years will pass closer and closer to Antares until it goes just over 1 minute of arc south of the star on October 19, 2117. Can you guess why the dates of these close conjunctions are always about the same and what causes the 8-year cycle? In the morning sky, Mars is just a bit over a degree north of Regulus on October 19. But what a dim reminder of the three great Mars-Regulus conjunctions of 1979-80 this is!

On the morning of October 22, however, the **Moon** (whose waxing light will ruin the Orionid meteor shower on the 20th) makes a pretty configuration with **Mars** and Regulus. The Moon's most interesting role this month will be as guide to a whole throng of planets and stars low in the east on the morning of October 26.

The three planets involved won't be seen for most of October; **Saturn, Jupiter,** and **Mercury** are in conjunction with the Sun on October 6, 14, and 18, respectively. But by the 26th, they rise surprisingly long before the Sun for observers in mid-northern latitudes: Saturn, 95 minutes; Mercury, 85; and Jupiter, 50.

The Moon, only about 1⅓ days before New, is closest to, and just north of, Mercury and Saturn — both at first magnitude. Which of the two do you estimate as brighter this morning? Watch Mercury brighten rapidly over the next few mornings.

Jupiter should be luminous enough to be spotted fairly easily below the other planets — it is already a full 8° east of its old companion Saturn, their Great Conjunction now just a memory.

A tight "trio" of Mercury, Jupiter, and the star Spica is unobservable on October 19 and 20 because all are then only about 4° from the Sun. Yet by the 26th, all have climbed high enough to be visible — though spotting Spica will be quite difficult. Search for it just a few degrees to the lower right of Jupiter that morning. The much brighter star Arcturus will be easily visible, far to the north of the Moon.

## the starry sky

October evenings seem especially dark and not just by contrast with days that are full of colored leaves. The southern sky is filled now with the most dimly and scantily starred realm of the heavens — the Great Celestial Sea or, more simply, **the Water.**

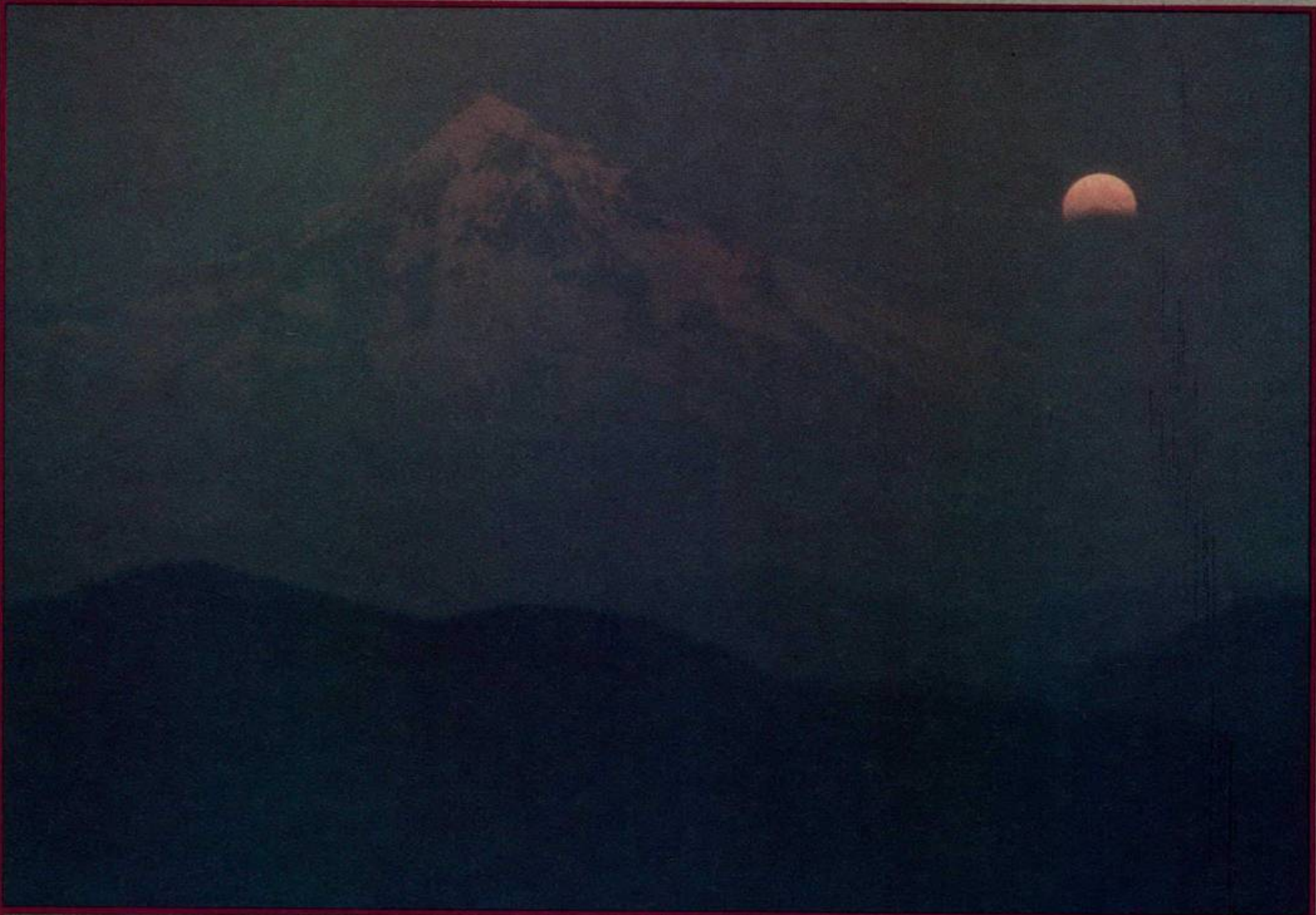
With its few stars, the Water reminds us of that deepest ocean of all — the ocean of space — but its name derives from the fact that all the constellations here are "aquatic" in nature.

Three large zodiacal constellations stretch across the region. First is **Capricornus,** a creature with the front of a goat and the back of a fish — we'll discuss it in detail later in Skylore. Next is **Aquarius** the water bearer who is comprised mainly of "streams" of faint stars in lines that extend southeast and southwest from a small grouping of 4th magnitude stars called the **Urn** or **the Water Jar.**

Not far to the east of this is a little circle of more 4th magnitude stars called **the Circlet.** This configuration represents the head of one of the two fish that form **Pisces** the fish. Pisces extends onward to the east to the 4th magnitude star Alrisha, where it takes a turn to the north to form the other fish.

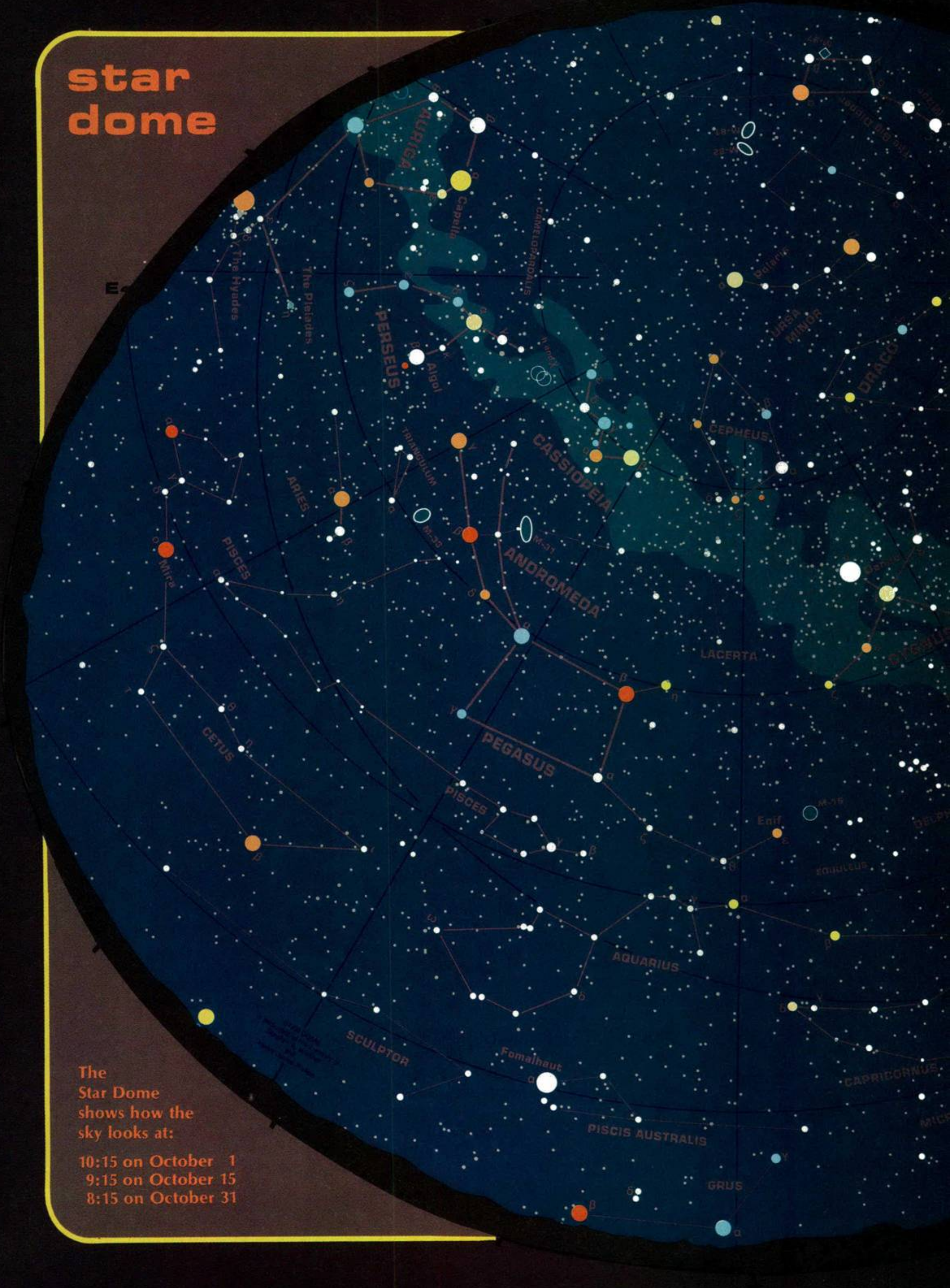
Aquarius and Pisces are rather difficult to trace even under fairly dark skies. But a perfect guide to finding them is the giant asterism of second magnitude stars located just above the Circlet. This is the **Great Square of Pegasus,** whose four members are (clockwise from the upper right [northwest] corner) Scheat, Markab, Algenib, and Alpheratz.

If you follow the long neck of upside



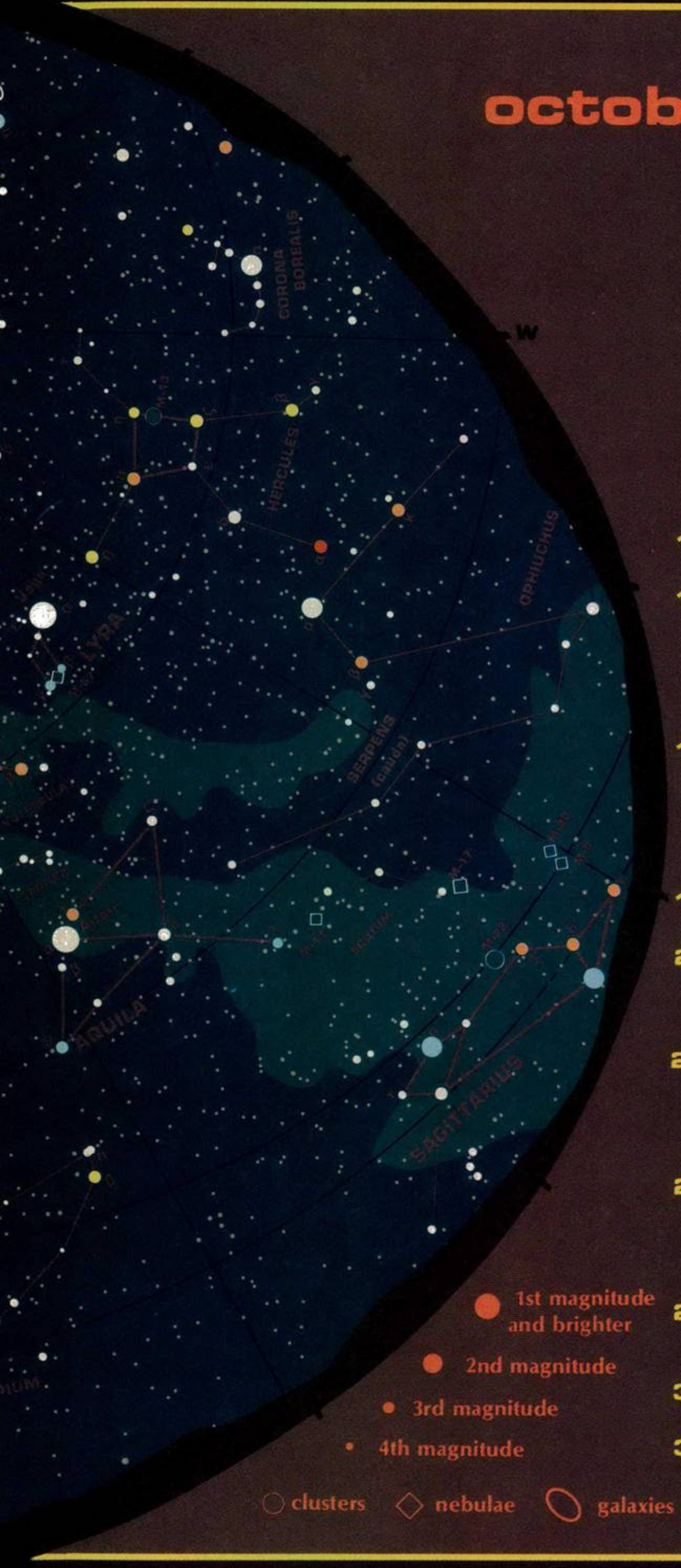
The partially eclipsed Moon hangs suspended before Mt. Hood in the early evening of July 16. Dennis Jamison made this photo with a ¼-second exposure at f/5.6 on ASA 64 film. The Northern Lights (right) as seen from Alaska at 3 a.m. July 23. J. Manacci and R. Beacher made this 20-second exposure with a 28mm lens and ASA 400 film. An unusual rocket contrail (below) was photographed on June 4 by Sandra Deakins from San Diego, California. She used a 100mm lens at f/2.8 and ASA 200 film for this shot taken 30 minutes after launch.

# star dome


E
AURIGA
Capella
CAMELOPARDALIS
The Hyades
The Pleiades
PERSEUS
Algol
M-81
M-82
Polaris
URSA MINOR
DRACO
CEPHEUS
CASSIOPEIA
TRIANGULUM
ARIES
M-33
M-31
ANDROMEDA
PISCES
Mira
Deneb
CYGNU
LACERTA
CETUS
PEGASUS
PISCES
M-15
Enif
DELPH
EQUULEUS
AQUARIUS
SCULPTOR
Fomalhaut
CAPRICORNUS
PISCIS AUSTRALIS
MIC
GRUS

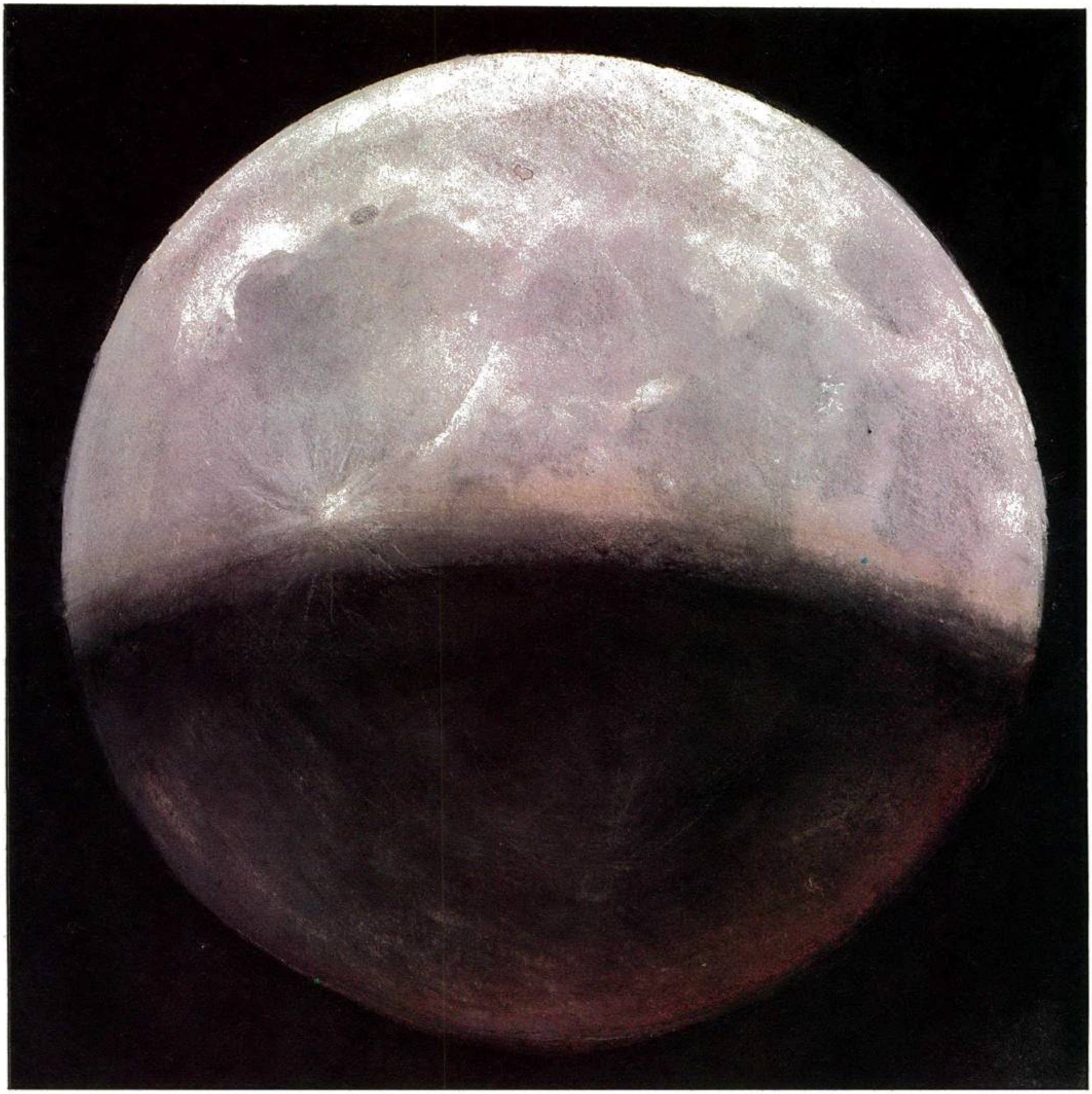
The Star Dome shows how the sky looks at:

10:15 on October 1
9:15 on October 15
8:15 on October 31


CORONA BOREALIS
HERCULES
LYRA
OPHIUCHUS
SERPENS (cauda)
SCUTUM
AQUILA
SAGITTARIUS
M-17
M-22
W
1st magnitude and brighter
2nd magnitude
3rd magnitude
4th magnitude
clusters
nebulae
galaxies

# october sky almanac

| | |
|---|---|
| **1st** | This evening a three-and-a-half day-old crescent Moon will pass north of Venus by about 7°. (Also see the 31st.) |
| **2nd** | The Moon is at apogee tonight: 251,862 miles from Earth. |
| **5th** | Saturn is in conjunction with the Sun at midnight EDT tonight and changes from an evening to a morning planet. |
| **6th** | First Quarter Moon comes at 3:45 a.m. EDT. |
| **13th** | Full Moon (Hunter's Moon) comes at 8:49 a.m. EDT. |
| **14th** | Jupiter is in conjunction with the Sun at 1 a.m. EDT and changes from evening sky to morning. Also, the Moon is at perigee tonight: 223,993 miles from Earth. |
| **18th** | Mercury is at inferior conjunction; it passes between Earth and Sun, changing from an evening to a morning object. Look for it low in the east-southeast just before sunrise a week or so from now. |
| **19th** | Last Quarter Moon comes at 11:40 p.m. EDT. |
| **20th** | Late tonight and in the early morning hours of the 21st, look toward the east for a few Orionid meteors. |
| **22nd** | Early this morning, the waning crescent Moon, five days and eight hours before new, will lie above and between Mars and Regulus. |
| **26th** | The Moon, a very thin crescent, will lie to the left of Saturn and above Jupiter just before sunrise this morning; both will be very low in the east. |
| **27th** | New Moon is at 3:13 p.m. EST. Also today: Mercury passes through perihelion. |
| **30th** | The Moon is at apogee this morning: 252,456 miles from Earth. |
| **31st** | The Moon, four days old, will pass north of Venus for the second time this month. Look in the evening sky after sunset. |



**Returning to an older method of observational record-making, Debra Williams of Gadsden, Tenn., made this sketch of the July 16 lunar eclipse as it neared maximum. Fine drawings can record detail in the bright regions while showing the hidden features in the umbra — something a photograph cannot do.**

down **Pegasus** the flying horse to the southwest and then make a slight turn to the northwest, you'll find the horse's nose marked by bright, second magnitude Enif (Epsilon [ε] Pegasi).

Continuing this new course about one more "neck-length" brings you to the tiny rhomboid-with-a-tail figure of **Delphinus** the dolphin, one of the peripheral members of the Water. But high in the west on October evenings is a far more splendid summer constellation, **Cygnus** the swan. Cygnus — like most birds at this time of year — is heading southward, down the stream of the Milky Way.

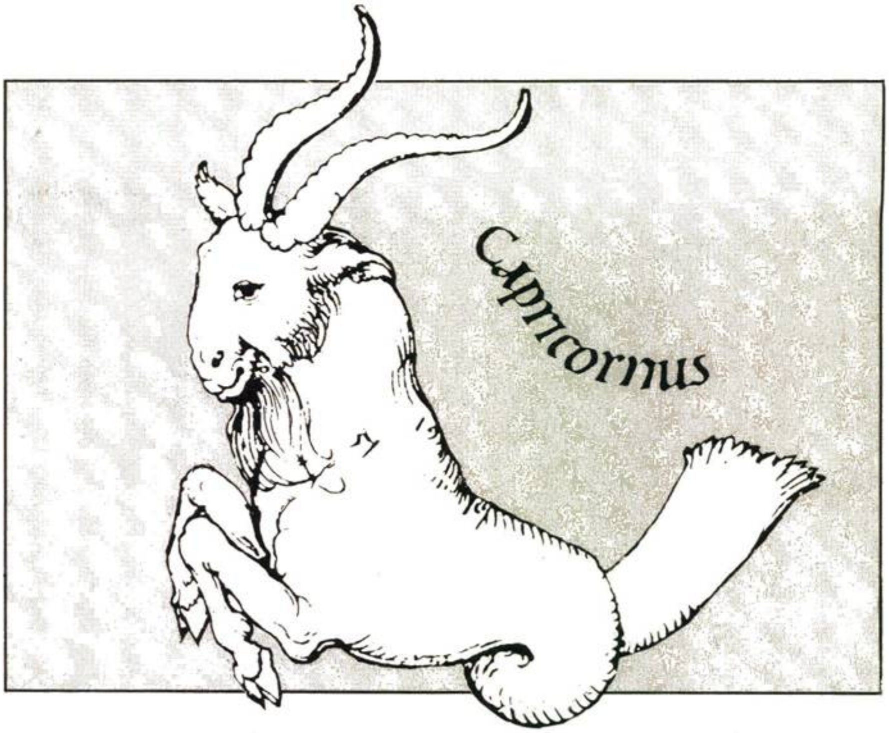
Meanwhile, over in the southeast and far below the Great Square, the sole first magnitude star of autumn is rising. It is **Fomalhaut**, a name meaning "the mouth of the fish," which indicates its position in **Piscis Austrinus** the southern fish. The great amateur astronomer Leslie Peltier has pointed out that for U. S. observers Fomalhaut rises in the southeast at about the same time as Capella rises in the northeast. Fomalhaut looks very lonely — I sometimes think of it as a solitary lighthouse on the southern shore of the Water.

Andromeda (the chained maiden) crosses the zenith late on October evenings and the gleam on the chain binding her arm is M-31, the **Great Galaxy of Andromeda**. This object appears as an elongated glow directly overhead for viewers in the latitude of New York City (41° N) at midnight, daylight time, in mid-October.

Her rescuer, **Perseus**, is climbing the northeast, shaped like a giant K with two bright gems, Mirfak and the variable star Algol. Her vain mother **Cassiopeia** the queen is a late evening letter M high in the north, sharing the meridian with her daughter. And just left of Cassiopeia is Andromeda's rather faint father, circumpolar **Cepheus** the king.

# skylore

What is the most ancient constellation that has survived to the present in the same form? Nobody knows for sure, but one of the leading candidates will probably surprise you because it is so dim. Give up? It's none other than Capricornus the sea-goat! The figure of Capricornus goes back to the most ancient times in history. The earliest lore connected with the constellation has something of the power of a primal legend — much like the tales of Genesis. And there is reason for the similarity: Capricornus is a survivor from the mythic atmosphere of that same distant age when civilization was young. The legend also has fascinating connections with the biblical flood and Eden.



Why has such a dim constellation endured for at least five or six thousand years? One important reason no doubt is its unusual isolation — few other stars lie nearby. But whatever the reason, in earliest known historic times, these stars became identified with Ea Oannes, the most powerful god of the Sumerians.

He was pictured as a goat with a fish's tail and is almost certainly the source of the constellation figure which has come down to us through the Greeks and Romans as Capricornus.

When the Babylonians eventually superseded the Sumerians as rulers of Mesopotamia, they claimed that their own god Marduk was the eldest son of Ea and had taken over many of his father's original powers and authorities. But in earlier times, Ea had been not only "Lord of the Waves," but also known by the title Enki, meaning "Lord of the Earth."

Ea, who saw all things, was the lord of wisdom and the protector of man. It was Ea who told the man Uta-Napishtim to build an ark in which to gather males and females of all species to survive the flood which Enlil the sky god would send to destroy the creatures of a world turned evil.

Isaac Asimov has mentioned the possibility that Noah's worldwide flood only concerned Mesopotamia and occurred perhaps in Sumerian times. He also speculated that the disaster could have been caused by a great meteor falling in the Persian Gulf. (Moreover, he points out, the traditional final resting place of Noah's Ark is in the ancient land of Ararat, upstream from Sumeria — and most ordinary floods would carry a ship *downstream.*)

Perhaps even more fascinating than the Sumerian story of the flood are the links with Eden. According to some scholars, Ea was considered not only as protector, but also as the one who created mankind out of red clay. (Adam, remember, is alleged to have been made from the dust of the Earth).

The evidence from Genesis itself indicates that the land of Eden — in which the garden was planted — may have been in or very near Sumeria. Also while the word *eden* means delight in Hebrew, it means plain in the unrelated language of the Sumerians. Scholars think the sumerians may have migrated from a hilly region like central Asia or Siberia, and might have referred to the flat land of Mesopotamia as Eden.

But how did Ea come to take the strange shape of the sea-goat, our Capricornus? According to Gertrude and James Jobes, he roamed the Earth as a goat to see all and hear all, but fought a battle against Kusariqqu, a monstrous fish-man, to win this part of the zodiac. His fish-tail developed when he assumed his conquest and swam in this region of the heavens.

We haven't space to examine much of the later lore of Capricornus, but it's worth noting how many of our English words are related to the constellation's name. *Capricornus* is Latin for horned goat, which distinguishes it from the star *Capella,* a female goat. (Some Greeks pictured Capricornus as all goat.) Eratosthenes identified the constellation with Pan, who grew a fish-tail when he leaped into the water to escape the monster Typhon and thereby gave us the word panic — but the same story is also told of Bacchus.

Some have associated Capricornus with Amalthea the goat which nursed Zeus, and whose horn the infant broke off and made into the cornucopia — literally the horn of plenty. But Amalthea and cornucopia have been more often identified with Capella.

Many words are derived from both the goat and horn roots of the name Capricornus. We say that a thing is *capricious* if it follows every whim — like a *capering* young goat. The poet Gerard Manley Hopkins speculated on the words that could be related to Latin *cornu,* horn, and was probably off the track about *crow, raven, heron, grain, grin* and *kernel.* But no doubt he was correct about *corner* and possibly *corona, crown,* and *head. Unicorn* is obvious, but would you have guessed that *cornea* (a part of the eye) was derived from the Latin for horn?

Capricornus has been a constellation for so long that there has even been a notable change in one of its stars. Alpha ($\alpha$) Capricorni, called Algiedi (Arabic for the goat — of course!), consists of two stars, magnitudes 4.2 and 3.6, which are 376" of arc apart — separable therefore by anyone with normal eyesight. This pair, however, is a remarkable optical double — the two stars are not physically related, because the brighter (Alpha$^1$) is about five times closer to us than Alpha$^2$. And R. H. Allen mentions that their separation was only about four minutes of arc at the time of Hipparchos, so the pair would have appeared single to most observers.

Camille Flammarion claimed that the Chinese viewed a conjunction of all five classical planets in Capricornus in 2449 B.C. (Capricornus was the ox in the ancient Chinese zodiac) And, according to the Jobeses, the Babylonians, who flourished after 2000 B.C., believed that the world would be destroyed by a great fire when all the planets met here.

Fortunately for today's observers, this did not happen, and we are here to enjoy the patterns and activity of the legendary sea-goat.

# ASTRONOMY IN FOCUS

### EE-oh, Eye-oh, Ah-oh

Sir / Permit me to enter the moon pronunciation controversy on the side of the angels, or at least of the Anglo-Saxons.

"EE-oh" sounds arty and stilted, even when Carl Sagan says it. It fits our ears and or mouth better to say "eye-oh," and that is the pronunciation given in Webster's.

In general, names with referents or cognates outside the classical pantheon should be pronounced like their everyday counterparts. This will help everybody feel more at home with them. This is not the same as saying that purely local dialects should dictate the correct pronunciation. After all, Io probably comes out "Ah-oh" south of the Mason-Dixon Line!

Hugh W. Thompson
Flushing, NY

### A Case for English

Sir / As a Latinist by education, I have been interested in the debate about the correct pronunciations for the moons of the outer planets.

Your readers should be aware that there are two principal methods of pronouncing Latin words in English usage. The "Roman" attempts to follow the ancient pronunciation; the "English" follows the analogies of normal English pronunciation.

To my mind, it is preferable that at least one or the other method be used consistently. Since the Roman method is unfamiliar to most American and British ears (does anyone pronounce *et cetera* with a hard c?), the English method seems most natural for astronomical use here.

In that case, John Mood's letter (April '81) gives the accepted English pronunciations. However, Paul Nobel's Um-BREE-uhl should, according to my sources, be corrected to UM-bree-uhl.

Martin E. Morrison
Oakland, CA

### Tethys' Genealogy

Sir / Tethys most definitely is a mythological figure. She is one of the Titans or, more specifically, the wife of Ocean. Born of Earth and Heaven, she bore Iapetus, whose sons Atlas and Prometheus are of no little import to man; Atlas carries the world on his shoulders, while Prometheus gave mankind fire. The sea nymph Thetis, whom Mr. Sterrenburg correctly mentions as Achilles' mother, was actually a great, great granddaughter of . . . Tethys! Mr. Sterrenburg seems to have assumed that Tethys was merely a misspelling of Thetis. This is certainly not the case.

Paul Burich
Menlo Park, CA

### Classic Pronunciations

Sir / The correspondence about whether Io should be pronounced EE-oh or EYE-oh, etc., is bound to seem like harmless vaporing to anyone who has some training in linguistics. Or perhaps not so harmless: this kind of thing may make people afraid to say the names at all lest some pedant jump down their throats.

We do not know exactly how the ancient Greeks or Latins pronounced their languages. We have working assumptions, based on reconstruction from daughter languages (such as modern Greek) and cousin languages (such as Sanskrit). For instance the "ph" in Phoebe probably was a "p" accompanied by a puff of breath; the middle vowel was probably spoken with a rising-then-falling tone (marked by late Greek grammarians with a circumflex accent); and the final vowel probably sounded something like the "ai" in our air.

The main point is that all this is basically irrelevant. As the words passed down through communities of people speaking Greek, Latin, French, English, they underwent the sound-changes that were part of the history of those languages. For instance, the pitch-accent of Greek disappeared and was replaced by a stress-accent; "ph" changed in pronunciation to "f"; both "oe" and the long "e" became in English (and also, curiously, in modern Greek) the sound of "i" in machine. One great wave of changes in English, known as the Great Vowel-Shift of the 14th to 17th centuries, moved all the long vowels in a kind of musical-chairs, so that ate, eel, and idle ended up where they are today; this is responsible for the great difference between English and the other European languages in the way it employs the vowel letters.

When you speak a name like Phoebe in the context of an English sentence, you are speaking an English word. (Similarly, if you are speaking Swedish, it becomes for you a Swedish word.) You should not make a sudden switch to and from some other sound-system, whose full rules you probably do not know. We have all heard people trying to use, in the middle of English sentences, the "proper Spanish" pronunciation of such words as junta and guerrilla; all they are doing is substituting one English sound for another.

You are at the end of a long tradition. If you substitute FOY-buh, or something of the sort, for the way *you would* naturally pronounce Phoebe (the way you would pronounce it when speaking to a living person, for it is after all a name still used), you are merely breaking the tradition and going back to some earlier point in it — or trying to.

You are part of a speech-community. In general, the best way to pronounce any word is as the majority of your speech-community pronounces it. Language is a system of communication; its purpose is to be understood.

One misunderstanding of a different kind in Mr. Sterrenburg's letter: Tethys is not an Anglo-American mistake for Thetis, though both were female deities of the sea and both names probably came from the same Greek root (meaning "put" or "dispose"), so fundamentally they may be the same personage. Tethys was one of the twelve Titans and consort of her brother Oceanus; Thetis was one of the fifty Nereids, or daughters of Nereus, who married Peleus and became the mother of Achilles.

Guy Ottewell
Greenville, SC

### Planetary Data

Sir / I have noticed that in the planetary data section of Through the Eyepiece you print two maps of the solar system. How are we looking at them, and what is the line extending to the right in each?

Carl Johnston
Ventura, CA

*Mr. Johnston / Both views are drawn as they would look from far above the Earth's north pole; from that position all the planets appear to orbit counterclockwise. The line marks the vernal equinox. When the Earth lies opposite that line — in other words, when the Sun appears to cross it — spring begins in the Northern Hemisphere.*

### Ooops!

On page 69 of the July issue, a typo increased the scale of the universe 1,000 times. As several readers have pointed out, the distance to the Virgo cluster of galaxies is 60 million light-years, not 60 billion.

Richard Franco took the photo of the Shuttle that appeared on page 5 of the August issue. David Rucker took the inset photo on page 18. On page 35, the photographer was John Gibbons — our apologies to all three. When submitting photographs to ASTRONOMY, please be sure to write your name and address on each and every print and slide. This will insure that all photographers receive proper credit for their work when it appears in the magazine.

behind the scenes

## astromedia grows

Susan Poole
Mary Kuklinski
Ross Parker Simons
Berry Brunk
Kristie Roth
Debbie Weinstein

In the past months, as ASTRONOMY has continued to grow, we've added quite a few people to our staff. We'd like you to meet them through Behind the Scenes.

Ross Parker Simons has been ASTRONOMY's copy editor since late 1980. He is responsible for making sure that the language in our magazine is gracefully expressed, properly spelled, and fully proofread. Ross also keeps the flow of copy moving smoothly from the editorial typewriters, through the production department, and out the door to the printer. (Hi! Mom)

Mary Kuklinski is our advertising coordinator. She handles everything having anything to do with advertising: from making sure that potential advertisers know about our magazine and setting deadlines and due dates, to helping them make sure their finished ads appear in ASTRONOMY with all the correct information.

To insure continuing circulation growth and proper distribution of ASTRONOMY, ODYSSEY, and TELESCOPE MAKING, Kristie Roth was hired as circulation director. When she's not buried in computer print-outs showing response percentages, she's working on new promotion packages for next spring and the fall beyond that.

To supervise our growing inventory of AstroMedia products and posters, we've hired a product manager — Susan Poole. Not only are we constantly thinking up new items that we might sell, but lots of other firms approach us asking us to market their stuff. Susan serves as a clearinghouse for all these ideas, and will direct new products from conception, through production to marketing.

Debbie Weinstein joined our staff as editorial secretary just before we moved to our new building. She came through the chaos with a smile — despite it all. Debbie handles a lot of editorial and general AstroMedia correspondence, and is taking a crash course in Messier objects so she can help us keep the photo files up to date.

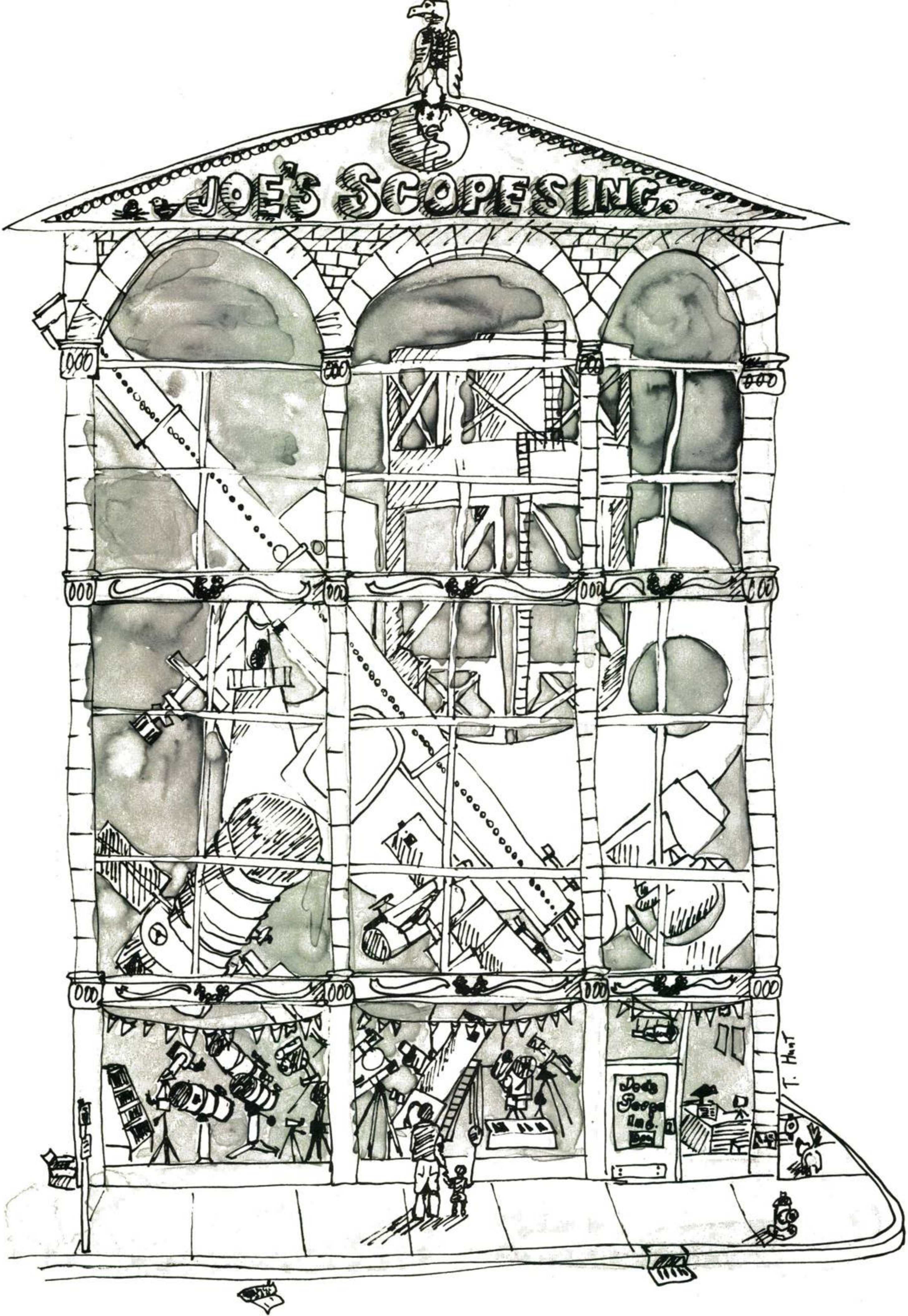
Most recently, Berry Brunk, our new assistant editor, joined the editorial staff shortly after we moved. Berry is a graduate of Virginia Polytechnic Institute in Blacksburg, an accomplished photographer, and a journalist. As he gets into the editorial process during the next few months, expect to see his by-line under his articles. Berry wrote this month's Equipment Atlas, our biannual update for beginners buying first telescopes.

It's an exciting time to be part of a small company such as AstroMedia. ASTRONOMY's growth, and the rapid growth of ODYSSEY, have made changes, new responsibilities, and new possibilities part of our daily fare. We are delighted to be able to bring you the best magazines and astronomy-related products that we know how.

Sincerely,

Richard Berry

Richard Berry
Editor


JOE'S SCOPES INC.
Joe's Scopes Inc.
T. Hunt

# 1981 telescope buyer's guide

equipment atlas

That last star party did it. There they were: Schmidt-Cassegrains, a handful of refractors, lots of tried and true Newtonians, a stout Dobsonian, and that handsome Maksutov — all of them producing beautiful images of the distant objects you've seen regularly through those binoculars you scavenged from the attic. You decided right then and there that you'd finally make the big plunge and buy your own telescope.

And why not? You've studied the sky seriously for over a year now, and with naked eye and binoculars you can locate the constellations and dozens of celestial objects with little effort. Now you want to see these objects — the Pleiades, the Moon, the planets — further enhanced by the splendid optics of your own carefully chosen scope.

But important as they are, a solid understanding of observational astronomy, the desire to own a scope, and the money to buy one are not the only qualities you need to be a good candidate for a telescope. You've also got to be "up" for it — in more ways than one. If it will upset you to learn that the totality of a lunar eclipse always seems to come at about 1 or 2 a.m., or that the comet of the century is going to make its only appearance three hours before breakfast, you may want to reconsider.

Telescopes are used while most of the world sleeps. And if you buy one, you should be prepared to use it — early in the morning or late at night — or your investment will just gather dust, and you'll have spent a lot of money on what will quickly become no more than a decorative piece of furniture.

If you've carefully considered all this and made the decision to buy, then you are ready for step two in the buying process — deciding what type and size of instrument is best suited to your astronomical needs.

First, ask yourself exactly what you want in a telescope. A small, portable one, or a larger and therefore more cumbersome instrument? Long or short focal length? Mirrors or lenses or both? Home-made or mass produced? Simple or gadget-laden? Answering these questions will point you in the right direction, but it might take some soul-searching to come up with the answers. The choice of a telescope — or any other precision optical instrument for that matter — should be considered as carefully as that of a house or an automobile. Certainly, it's just as personal.

Next, let's talk about the bottom line — how much can you afford to shell out for that contraption. There's no need to sell your car or take out a second mortgage on the house, but you want to be sure that you spend enough to get a good, solid astronomical instrument. Otherwise you might just as well throw your money away. The best rule of thumb is to wait until you can accumulate enough cash to cover the cost of the telescope ideally suited to your needs. It's better to wait until you can afford the one you want rather than to rush out and buy the first one on sale at Discount World. (Your other option, if you're short of cash, is to build your own telescope. Generally you can cut the cost by 50% and in some cases even more.)

Even if money is not a problem, you may want to limit the size of your instrument for other reasons. How could you transport a 20-incher when you drive a Honda? Never mind that — how would you even carry the thing? And what about storage? You might have to park your car out in the snow so the telescope can be snug and dry in your one-car garage. If you live in or near a city, you would surely want to take your scope away from the city lights to realize its full advantages for serious observing. Do you have a friend with a farm — or will you be shot at while trespassing at two in the morning? There is certainly more to consider than meets the eye.

### The "Classic" Choice

Now that you know the logistical problems of ownership, it's time to get down to some hard trade-offs about the types and sizes available. Traditionally there have been two instruments considered "right" for beginners. They are the 2.4-inch refractor and the 6-inch reflector. Both have merits depending on your needs.

Small refractors are lightweight and highly portable — ideally suited for someone who lives in an apartment or other sort of high-rise. They also have a self-contained light path free from convection currents that degrade the image. But the price of a good refractor — or even a bad one — runs considerably higher than that of a reflector.

A good 2.4-inch store-bought refractor costs between $275-400. Many come equipped with an alt-azimuth mounting — one that goes up and down and back and forth, which is not well suited to photography. It would be wise to anticipate the need of an equatorial mounting — one that follows celestial objects with one motion.

Though equatorial mountings are more expensive, they give greater control over tracking the telescope's highly magnified image. You can see what a boon the equatorial is by trying to hand-guide someone else's scope on a double star at 300x; you'll spend more time keeping the object in the field than looking at it. Also, if you have a strong desire to try astrophotography (or anything requiring constant tracking with a clock drive), then the equatorial mounting is best for you. They are expensive and heavy, but well worth their weight for the tracking they provide.

Larger refractors soon move outside the realm of affordable beginner instruments. The step from 3.1 to 6 inches skyrockets their cost from $1000 to $6000. As an additional cost, any refractor much above 4-inches should be permanently mounted, because its sheer size will make it very difficult to transport; four-inchers will probably be at least 5′ 6″ long and a 6-incher at least 8 feet.

### Newtonians

Because of these cost and size drawbacks, Newtonian reflectors long ago became the standard amateur instrument. They are easy to build and use because their design is simple. They contain two glass mirrors — one curved, the other flat — both aluminized to make them reflective.

Early Newtonian mirrors were made of speculum metal, which wasn't very reflective. Improvements in technology in the late 18th century led to silvering of astronomical mirrors — a process too inefficient and costly today. It wasn't until the 1930s that the aluminizing process was developed, making possible inexpensive and long-lasting reflective coatings.

## mail order caveat

Since mail order is the most popular way to buy a telescope, a few words of warning are in order. Telescope manufacturers are notorious for having production problems which slow down their delivery schedules. Although they have the best of intentions, it is not uncommon to wait 6 to 9 months for a telescope that you paid for in advance. It is to your advantage not to pay the full price in advance, but arrange to pay 50% or more on delivery.

Delivery setbacks can stem from a variety of unavoidable problems — all of them frustrating to you. Some companies aggravate the problem through unresponsive complaint departments. Few things are more infuriating than to be assured over the telephone many times that your new telescope is on the way and then later call and find it was never shipped.

As a mail order purchaser you are protected by the law, and your rights are clearly defined. Any product ordered across state lines comes under the jurisdiction of the Federal Trade Commission. Under federal law, the supplier must send either the products ordered or a full refund including any shipping, crating and handling charges within 30 days. Alternately, the supplier can state, in advance, a delivery time exceeding 30 days, but it must be fully agreeable to the buyer. If you experience such a problem, keep in mind that you have rights and can demand action. The law is on your side.

If you want to buy a reflector, a good starting size is a 6-inch. With such an instrument, all the Messier objects will be visible along with an impressive amount of detail on nearly every planetary surface.

Usually supplied in focal ratios ranging from f/5-f/10, the tube length ranges from 3 to 5 feet long and, with a solid equatorial mount, the whole telescope may weigh up to 100 pounds. But when dismantled into their components, these scopes are very manageable. The cost of a good 6-inch f/8 reflector runs from $300 to $600 including shipping and crating. Of course, the varying prices for models on either end of this range are dictated by how few or how many accessories the instrument has.

Today, more and more observers lean toward 8 to 10-inch reflectors. With a scope this size, you'll see a lot of planetary detail — Jupiter's Red Spot will pop out at you, and the martian polar caps will shine in your eyepiece. The bigger mirror collects more light rays coming in from galaxies and nebulae, and you'll see fine views of these deep-sky objects every night. Scopes this size — with prices running from $500 to $1600 — are usually supplied with equatorial mounts and clock drives. Their tubes will be from five to eight feet long, and the whole apparatus — mounting and scope — might weigh several hundred pounds.

Large reflectors are tempting because they can produce some of the striking details visible in observatory instruments, and today many reflectors from 12 to 18 inches of aperture are in the hands of nonprofessionals. But big instruments require dark skies and therefore must be portable or permanently mounted in a dark sky location. If you're thinking of purchasing such a telescope, you should consider it carefully since it will require a much greater commitment than a smaller scope. Prices for instruments this size run from $1600 to $5000 if purchased commercially.

### Reflectors vs. Refractors

The debate over reflector *vs.* refractor superiority has been raging for centuries. Refractors are praised for their crisp, highly magnified images of planetary surfaces or double stars. However, modern reflectors also give excellent images and are more mobile. Whatever the type, light-gathering power is dependent on the size of the aperture. A 6-inch refractor costs a lot more but gathers no more light than any other 6-inch scope. So if light-gathering power is a prime consideration for you, then the huge price disparity alone should rule out the refractor — for the $6000 you might spend on one, you could buy a 16-inch reflector and use the rest of the money to build your own observatory.

Once again, with patience and some mechanical aptitude, a good reflector can be made at home about half the cost, even if you don't grind your own mirror and build it from the bottom up. There are many suppliers of telescope parts and several notable books that can help you. If you choose to build rather than buy you'll also realize another benefit — you'll become intimately aware of your instrument's design. The thrill of viewing a crisp image through your own handmade mirror is exquisite, and even if you don't make the mirror yourself, you could buy the optics and then build the rest of the telescope around them. As another plus, knowing exactly what materials were used and following your own plans for construction will make you something of an expert. The time you'll spend on weekends and during the evenings will seem a small price to pay when you finally achieve "first light" through your own creation. And of course the money you save can be put toward eyepieces, accessories and a good star atlas.

### Lens/Mirror Hybrids

If the cost of a refractor or the size and weight of a Newtonian reflector don't fit into your plans for buying a telescope, don't despair. There are other optical configurations available. All these telescopes are hybrids and go by a variety of exotic names like Schmidt-Cassegrain and Maksutov. Each of these instruments uses a combination of mirrors and lenses to produce the image, rather than relying on one type of optics alone. The construction of these mirror-lens systems is tricky, but over the past ten years, several companies have found ways to mass-produce these telescopes and have greatly lowered their cost and made them more accessible.

This type of telecope is still expensive, but offers some advantages that may outweigh price. First of all, each features a folded light path so their tube lengths are reduced from six feet to only two or three. Their compact size makes them ideally suited if you want a medium or big aperture instrument with a high degree of portability. Naturally, the cost of this advantage goes up rapidly with the size of the scope, but most manufacturers have small aperture, ultra-portable models priced in the medium range — $400 to $900.

### Schmidt-Cassegrains

Schmidt-Cassegrain telescopes use

both mirrors and lenses. A thin lens at the top of the tube transmits light back to a large mirror that reflects it back to a smaller mirror located in the center of the main objective. The small mirror then reflects the image into the eyepiece and the eye of the observer.

The tube of an 8-inch Schmidt-Cassegrain is about two feet long and weighs around 10 pounds. These telescopes are usually supplied with a fork mounting that the tube swings through.

Such a compact instrument is a favorite to take on observing trips and to star parties. Easy to transport and quick to set up, the model is a familiar sight at every telescope gathering. One person can manage even a 14-inch Schmidt-Cassegrain and, when broken down into its component parts, the scope will fit easily into a compact car.

Prices run from $600 to $1200 for instruments with objective diameters of 5 to 8 inches. Larger Schmidt-Cassegrains, between 10 and 14 inches, usually cost $2000 to $6000.

### Maksutovs

The Maksutov also uses two mirrors and a lens, but its optical configuration differs from that of the Schmidt-Cassegrain. Instead of a thin and nearly flat corrector, the Maksutov mirror is thick and deeply curved. This scope is extremely compact and is the choice of several telephoto lens manufacturers. Typical sizes commercially available range from 3 to 7 inches of aperture with a tube assembly only a foot or so long. One manfacturer offers a 12-inch Maksutov, but at a very high price.

The image produced by a "Mak" is clean and crisp and resembles that of a refractor. Its closed tube and extremely small size makes it ideal for a city-bound stargazer who wants to see crisp planetary images and clearly separated double stars. Dollar for dollar, however, Maksutovs are more expensive than other types, and their small objective size means they can't gather much light. Most are exquisitely crafted but their $500 to $3000 price tag often places them beyond the reach of most beginners.

Two other types of telescopes are making very strong advances on the telescope scene — the rich-field telescope (RFT) and the Dobsonian.

### RFTs

RFTs have been around for decades, but are catching on in popularity again now. They are simply reflectors with short focal lengths — usually around four times the aperture. The advantage of an RFT is that it takes a large aperture telescope and scales it down to a more manageable size. A typical 6-inch f/4 RFT is only two feet long, and can be handheld. The short focal

## glossary

**Alt-azimuth mount** — A mounting that moves up and down and right to left on perpendicular axes.

**Aperture** — The size of the main light-gathering element of the telescope, usually given in inches or millimeters. Larger aperture telescopes are capable of resolving fainter detail and gathering more light.

**Catadioptric** — A telescope using a combination of mirrors and lenses to form an image

**Clock-drive** — An auxiliary motor that drives the telescope at the same rate the Earth turns. Clock drives are used with equatorial mountings to allow telescopes to track on the desired object.

**Coated** — A term that indicates a very thin coating, usually of $MgF_2$, has been applied to a lens to reduce unwanted reflections. Coated optics are important for refractors and eyepieces since they give brighter images than uncoated optics.

**Dobsonian** — A Newtonian telescope that swings up and down between side bearings and is mounted on a simple, sturdy rotating platform.

**Equatorial mount** — A type of mount that allows a telescope to track the stars easily because one of its axes rotates parallel to Earth's rotation.

**Eyepiece** — The small lens that you look into. The focal length of an eyepiece affects the magnification of the telescope. Several are needed for a good range of magnifications.

**Focal length** — The optical distance between the main light-gathering element and the place where the image is formed. Folded optics have a long focal length since light rays bounce several times inside the tube.

**Focal ratio** — Focal length divided by the aperture of the telescope.

**Magnification** — The increase in angular size of the image when you look through the telescope. To determine the magnification of a telescope, divide its focal length by the focal length of the eyepiece. Different eyepieces give different magnifications.

**Maksutov** — A type of telescope that uses a mirror, a deeply-curved correcting lens, and a smaller mirror to form an image.

**Mount** — Any of a variety of platforms that support the tube and optical assembly of the telescope itself. See alt-azimuth, equatorial, Dobsonian.

**Newtonian** — Named after Sir Isaac Newton, this type of telescope uses two mirrors to form its image. The main mirror is parabolic (concave) and the secondary is small, flat and placed at a 45-degree angle near the top of the tube. The eyepiece is at the top of the tube.

**Objective** — Another term for the main light-gathering element in any telescope. Its size dictates the amount of light collected.

**Reflector** — A telescope that uses a mirror to form the image. The mirror's shape must be accurate to a few millionths of an inch.

**Refractor** — A telescope that uses a precision lens, placed at the top of the tube, to form its image.

**RFT** — Abbreviation for rich-field telescope. This describes any number of telescopes with a relatively short focal length. They are well suited to viewing large, dim objects because they have a very wide field-of-view and can be used at low magnification.

**Schmidt-Cassegrain** — A type of telescope that uses a mirror, a thin correcting lens, and a smaller mirror to form an image.

**Ocular** — Another term describing the eyepiece.

**Suggested Reading:**

Howard, Neal. *Telescope Observer's Handbook and Star Atlas.* 1975
Ingalls, Albert. *Amateur Telescope Making 1,2,3.* 1978
Menzel, Donald H. *A Field Guide to the Stars and Planets.* 1964.
Moore, Patrick. *The Pocket Guide to Astronomy.* 1980.
Muirden, James. *The Amateur Astronomer's Handbook.* 1974.
Olcott, William T. *Field Book of the Skies.* 1954
Satterthwaite, Gilbert, ed. *Norton's Star Atlas.* 1973

length also means that it can produce low magnifications with normal eyepieces.

The view through an RFT is breathtaking — a very bright image in a wide field-of-view. For observing nebulae, galaxies and other extended objects, RFTs are ideal. With large diameter mirrors they can collect a great amount of light so sky objects unseen in smaller scopes seem to pop right out. RFTs are excellent instruments for general scanning or viewing star clusters and other large and faint objects.

RFTs are sold commercially, but they are also easy to make. Many people use one to supplement the restricted field of view of their primary instrument, and often mount them in tandem or "piggyback" to a larger scope. RFTs combine the advantages of large binoculars with the resolving power of a telescope.

### Dobsonians

The emergence of the Dobsonian — the most significant advance in the telescope in the past 10 years — has brought about an observing revolution. Although the design took a while to catch on, the popularity of these instruments is now rising rapidly because they offer several distinct advantages. The mortar-shaped Dobsonian could be called the "consumer" telescope, because it combines large size and relative ease of portability and operation in a telescope with a lower price tag than any other competing type.

How is this done? The key is in the mounting — in fact, the telescope is named for John Dobson, the man who designed the mounting. A Dobsonian is simply a Newtonian reflector that sits on a rotating pseudo-alt-azimuth mounting rather than a complex and heavy equatorial mount. In it, light, readily available, and inexpensive materials like plywood, plastic or cardboard replace the expensively machined parts found in other scopes.

The cost of any telescope is divided between the optical tube assembly and the mounting. On a Dobsonian, the cost of the mounting is significantly reduced because it's so simple. And the design is incredibly easy to use — not only is it steady, but finding sky objects is easy because you just point and look. The telescope stays where you put it without wobbling or slipping.

Easy set-up is also a Dobsonian virtue. Instead of aggravating yourself by having to align an equatorial mounting on the pole star, you simply plop down your scope and immediately start a peaceful night of observing.

Finally, the price is right. You can assemble a 6-inch Dobsonian for under $200 — everything included. And you can put the money you save on the mounting into high quality optics. The net result is that you get a much larger aperture telescope than you thought you could afford. Is it any wonder the popularity of the Dobsonian has skyrocketed?

After this discourse on Dobsonian capabilities, you are probably expecting a hitch. Well, there *is* a small one. Astrophotography is difficult with a Dobsonian because the telescope cannot track by itself. But if you're not aching to start taking pictures, you could be very happy with a Dobsonian. Later, as your ambitions grow, you can invest in an equatorial mounting for it, build one for it, or buy a second telescope to give astrophotography a try.

### Time, Money, and Patience

As you can see, buying a telescope is a major step in your astronomical hobby — the cash outlay alone makes careful consideration a must. The best way to stimulate interest in and increase the enjoyment of your hobby is to get a telescope that will be easy to use, will be capable of resolving the objects you want to see in great detail, and won't strain the time you can give to observing. For that first telescope, think small and think simple. If it takes you 45 minutes just to set up your telescope, then that's 45 minutes less you have for the stars.

Telescopes should supplement your viewing habits, not destroy them. Jumping in too deeply is a mistake that many beginners make — only to find out they don't want to commit their time to staying outside late at night and freezing their toes off. Thinking twice about your habits and love for astronomy will also help you with your decision. If binoculars or your unaided eyes alone satisfy your observing needs, then you may happily observe for years without any more expense. But if you feel a telescope will open more windows on the universe and help you derive greater pleasure from your hobby, then by all means buy the scope you want and head for clear skies.

*— Berry Brunk*

### the new way to buy a telescope

There used to be a time, long ago, when budding amateur astronomers had to make their own instruments. There just weren't any telescope manufacturers around. This kept the number of sky-watchers small. As time went by, several enterprising businessmen saw a demand, and slowly a few companies sprang up to cater to this limited market. Prospective telescope purchasers read the advertisements these companies placed in their favorite magazines and flooded them with orders. In a working example of commerce, both groups prospered.

Because of the availability of supplies, the number of "backyard" astronomers grew considerably in the next decade. At national and regional gatherings you could see home-brew telescopes right beside the slickly machined commercial models. Gatherings like these whet the public's appetite for larger and better instruments.

All was as it should have been. The number of telescopes made each year virtually matched the number of enthusiasts who wanted one. You sent in the order form from the back of a catalog, enclosed a certified check and then waited. In a little while your telescope arrived at the freight depot and you would rush down to save it from the ravages of transportation.

Then about ten years ago something happened — and it happened fast. Huge numbers of orders poured into the manufacturers. Production could not keep pace with demand. Delivery times became longer and longer, and sometimes it took more than a year to receive a telescope.

About this time other entrepreneurs saw the need for retail outlets to sell telescopes directly to the public. The manufacturers liked this idea since it would get irate customers off their back. They agreed to sell telescopes to retailers at wholesale costs, and the telescope store was born.

Today we can drive down to the nearest specialty store and see before us varieties of telescopes we once knew only from small black-and-white photos. We can actually touch, and yes, even star test the image of the particular model our heart is set on. With 10% down and monthly payments, everyone can have a telescope.

There are those who decry telescope stores as evidence of cheap commercialism, but these outlets serve a purpose. What was once a calculated gamble can now be a well-researched purchase — and you can walk out the door the same day with your new scope, ready to use it as soon as the Sun has set.

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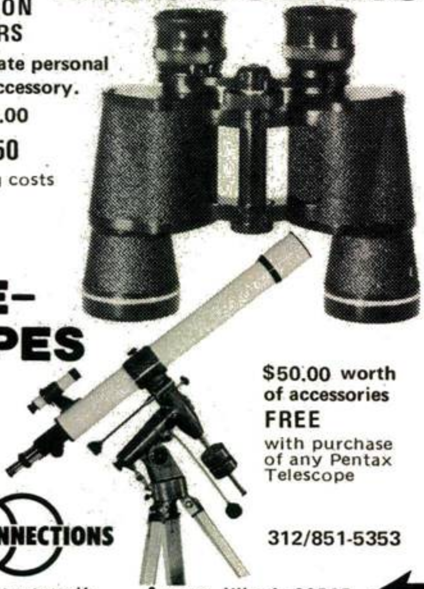

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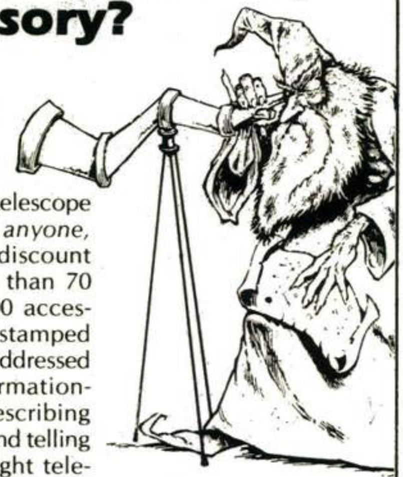

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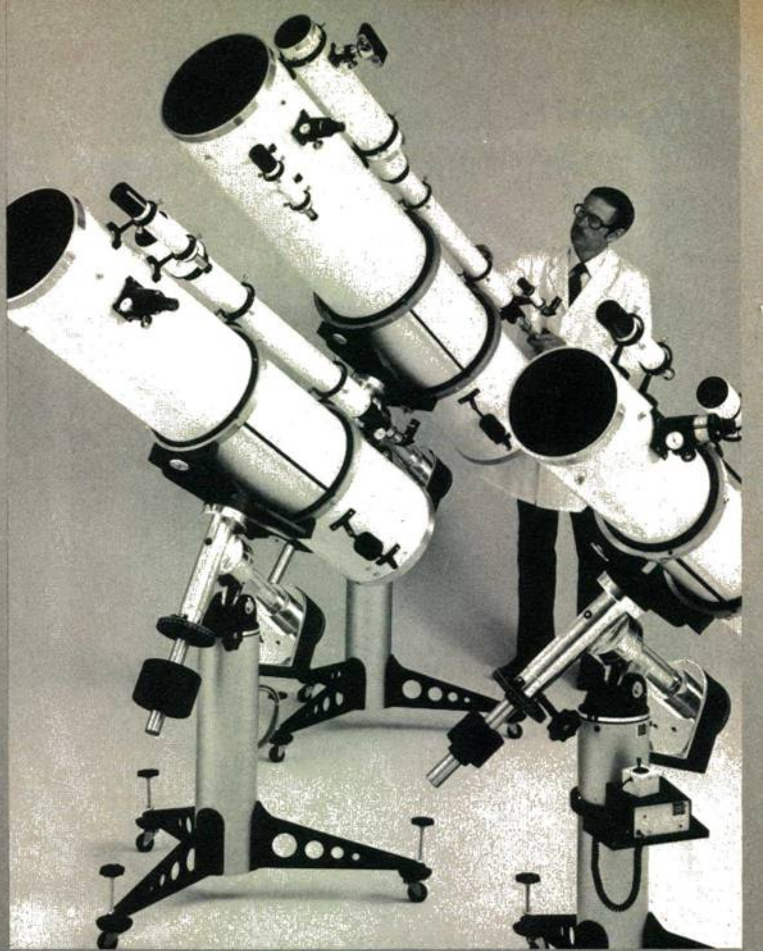

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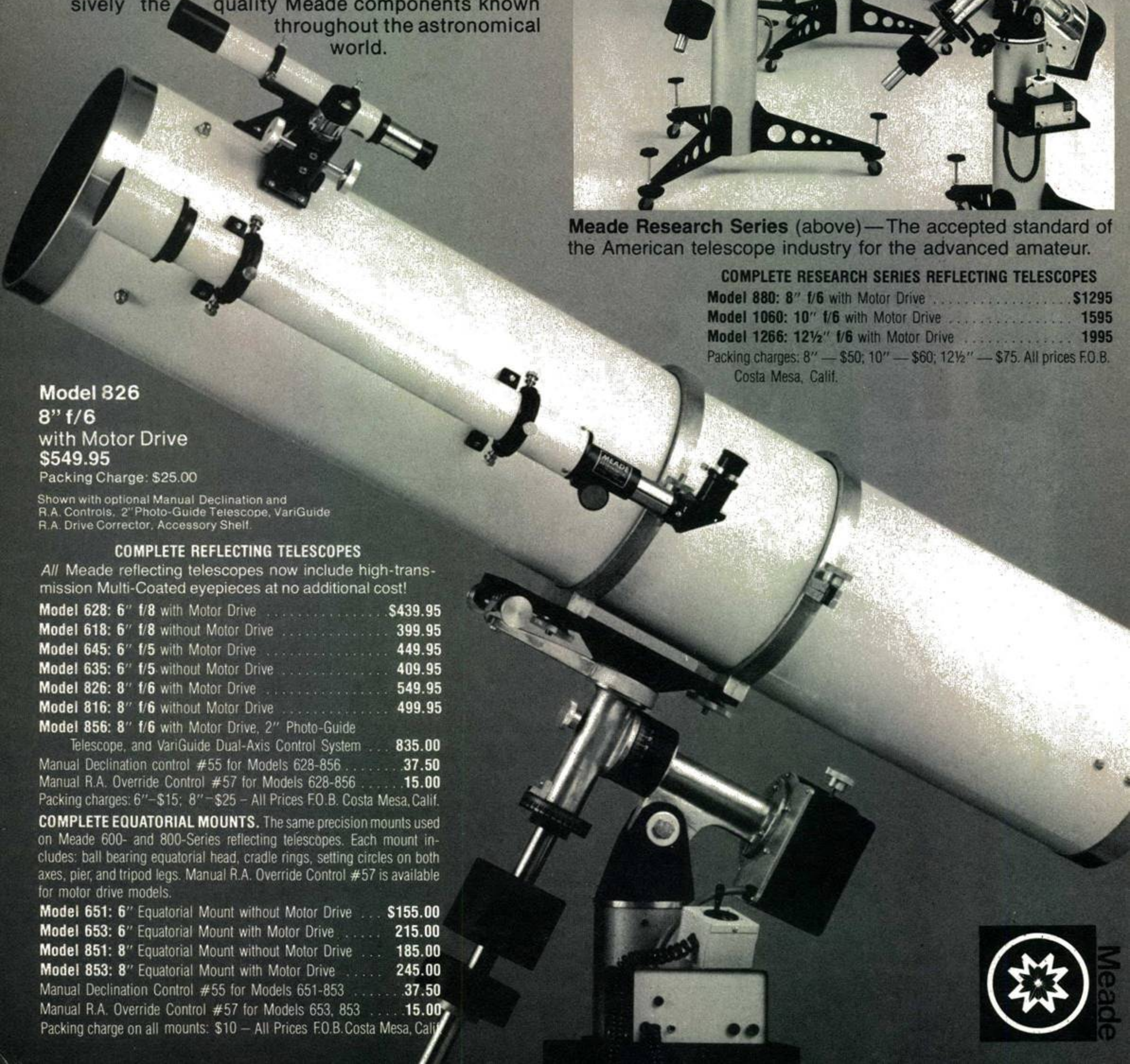

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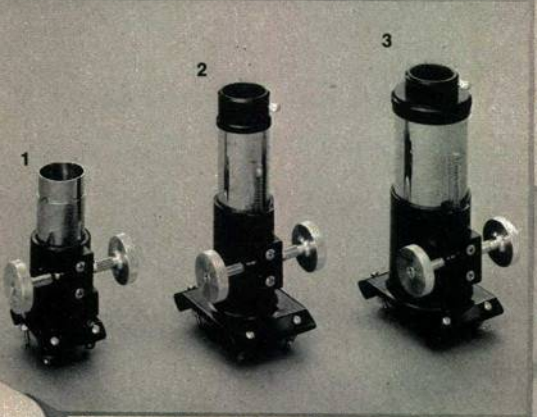

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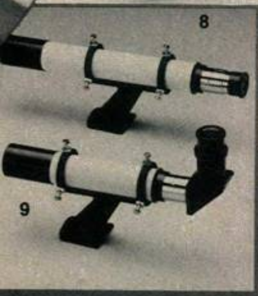

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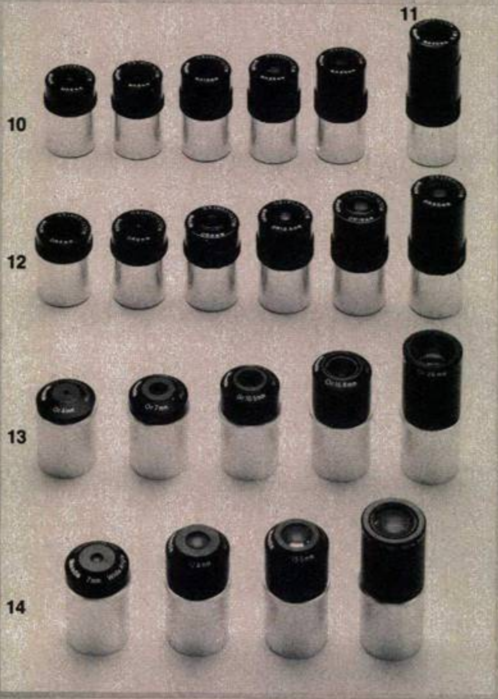

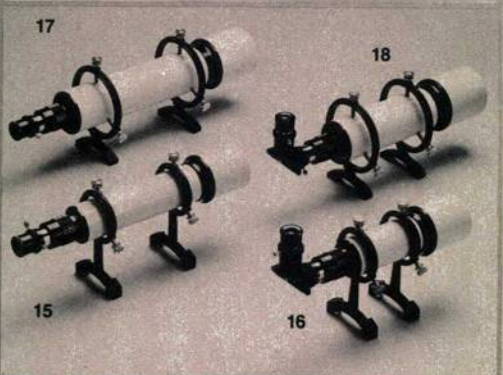

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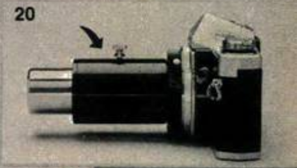
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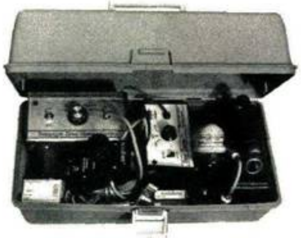

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2001

# starting an amateur astronomy club

### by
### Gail O. Clark

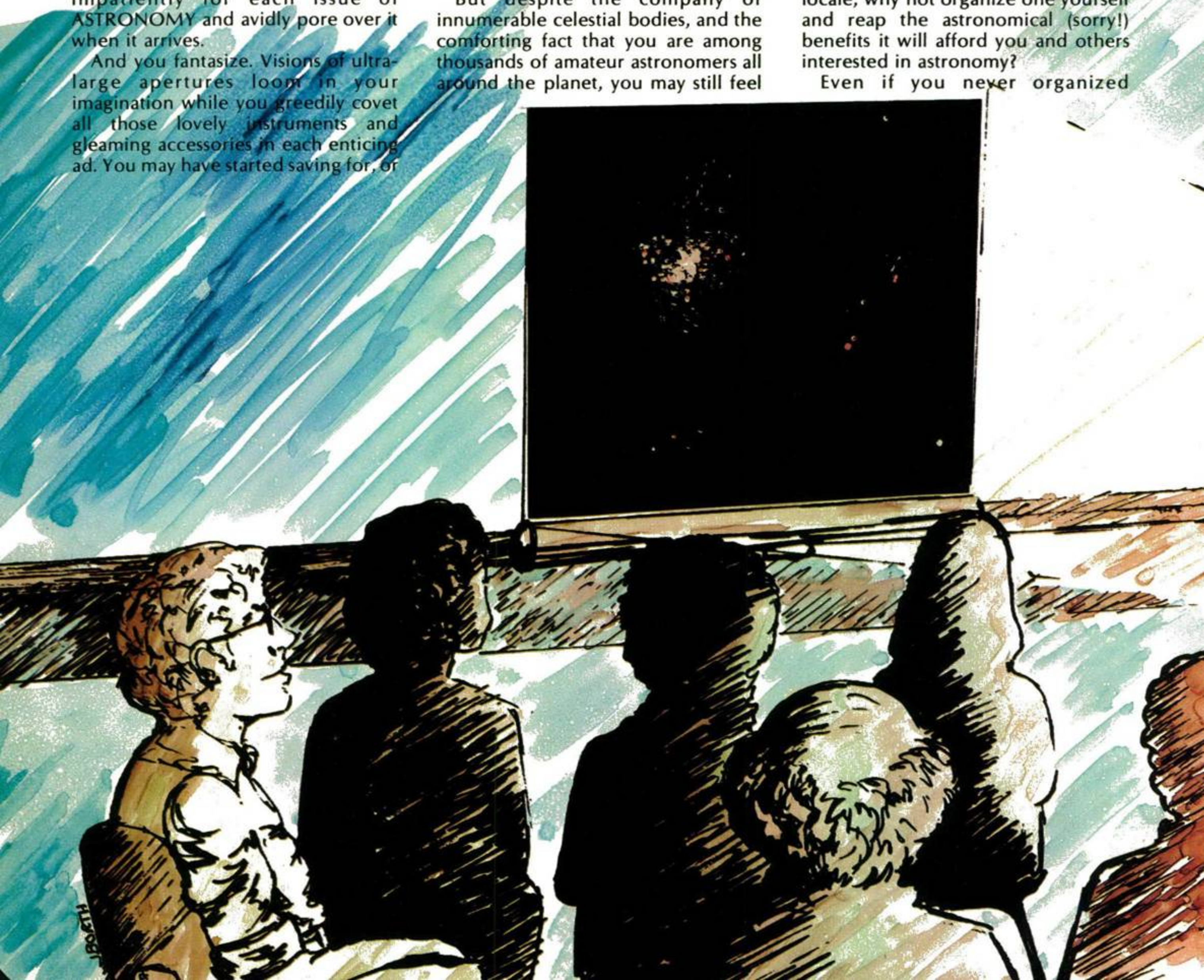
So the star bug has bitten, and you are now numbered among the legions who have discovered the enchantment and hypnotic attraction of the universe. You have accumulated books, posters, star charts, and assorted paraphernalia. You wait impatiently for each issue of ASTRONOMY and avidly pore over it when it arrives.

And you fantasize. Visions of ultra-large apertures loom in your imagination while you greedily covet all those lovely instruments and gleaming accessories in each enticing ad. You may have started saving for, or have already purchased a telescope. And perhaps you perform a nightly skyward-looking ritual: straining to peer into the cosmos even though your window to the universe may only be a swiftly moving hole in the cloud cover.

But despite the company of innumerable celestial bodies, and the comforting fact that you are among thousands of amateur astronomers all around the planet, you may still feel alone. This may be simply because you haven't met anyone else who has a similar fascination with the sky. Fortunately, there is a remedy for your starlight solitude — the astronomy club.

If there is no existing group in your locale, why not organize one yourself and reap the astronomical (sorry!) benefits it will afford you and others interested in astronomy?

Even if you never organized



anything more complex than the family picnic, putting together an astronomy club won't be that difficult a task. It takes basically three things besides the enthusiasm you already have: advance work, publicity and follow-up. These three steps will be easy if you follow some guidelines.

Advance work is simply making sure you'll have everything you need when you need it — from a building to meet in all the way down to pencils and paper. Your first mission will be to secure a safe, roomy, central location for your meeting — preferably with free parking nearby. If you can find a place to meet free, take it. Don't overlook public buildings such as recreation centers, libraries, churches, schools or museums.

If film and slide projection equipment is available, so much the better. Also, a chalk board may come in handy. You're there to communicate, so any aids, visual or otherwise, will be useful.

Put together a display of astronomy-related items: books, pamphlets, photographs, and magazines. A printed or dittoed handout of upcoming celestial events such as meteor showers, comets, and conjunctions would be a nice additional touch. Prepare an agenda for your meeting and have plenty of copies on hand.

Do a bit of research beforehand and try to select a time which will not conflict with other local events. If possible, get a list of optional times and dates your meeting place will be available in the future. This might allow you to set up a permanent schedule at your very first meeting.

As soon as you've nailed down a location and a meeting time, it's time to start phase 2: publicity. Your initial meeting must be the most widely publicized, because you'll want to inform as many people as possible so the club can grow on its own. A brief item in local newspapers plus a determined program of delivering public service announcements (psa's) to radio and television stations will greatly aid your cause, so properly written news releases and psa's are essential. (See box.)

These typed, double-spaced notices should be sent to stations and newspapers *at least* one week prior to your first meeting. Releases should be sent to the attention of the newspaper's city editor. (Don't forget the weekly newspapers in the suburban or nearby small towns, and hand-deliver your releases, if possible.) Send TV and radio releases to the attention of the news director and psa's to the public service director.

As an additional publicity boost, make some 8½″ by 11″ posters and put them on public bulletin boards and other locations where they will be seen by as many people as possible.

When the big evening arrives, what can you expect? If you've done your homework and also have a bit of good luck, you will see lots of interested folks of all ages and at various levels of astronomical knowledge.

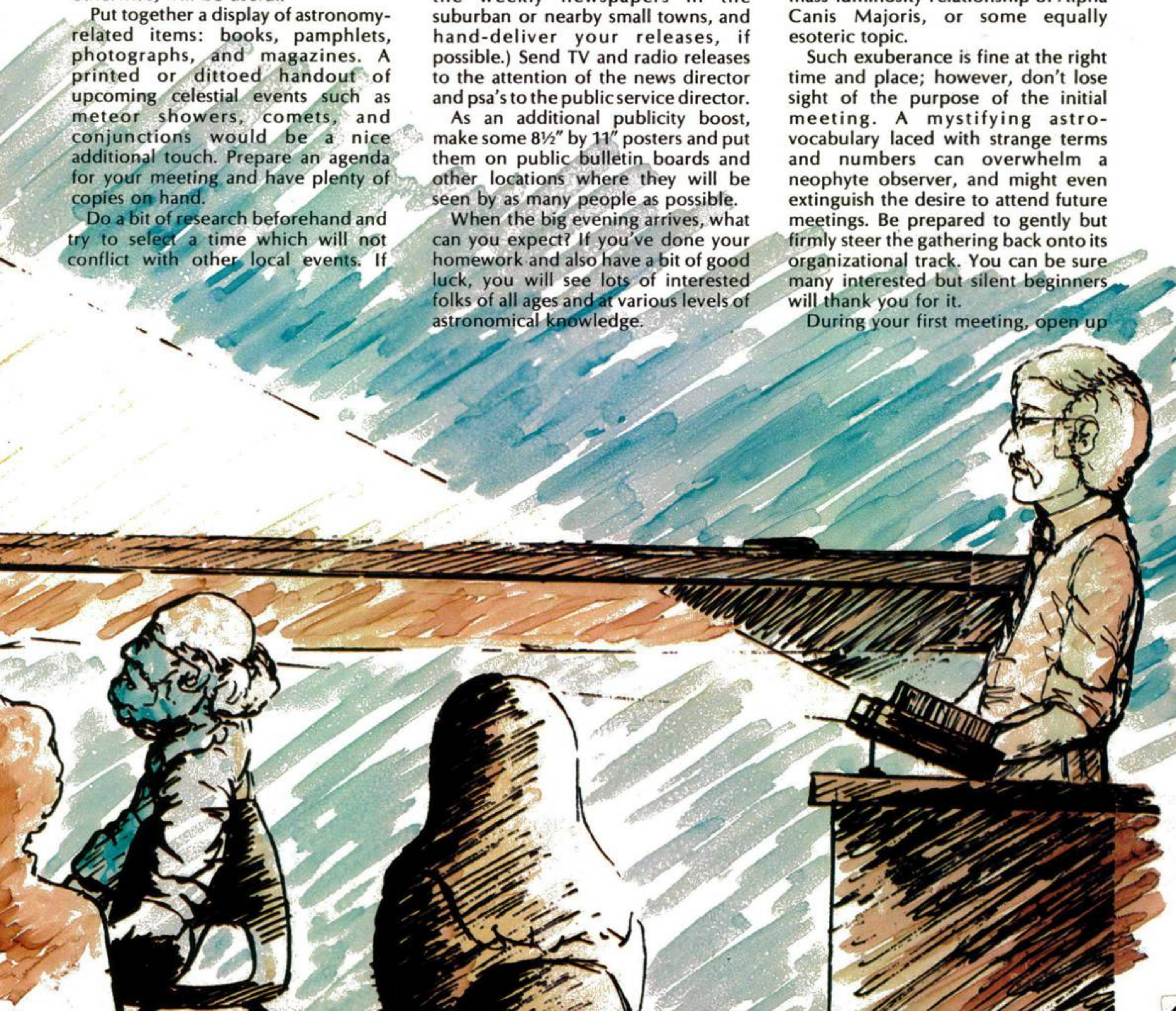
As prospective members come in the door, have them fill in your sign-up sheet — the one you made ahead of time from a legal pad by listing NAME, ADDRESS and PHONE at the top. This kicks in your follow-up phase. Later you'll call all those signed up about star parties, future meetings, and volunteer work that needs to be done. Your sign-up sheet is the key to keeping your club alive. Use it often.

Ask each person to introduce him or herself to the group. Try to find out their personal expectations from the club and their own area of interest. A description of any optical gear they may own, and any prior experience with amateur groups, may also help warm things up.

In that sea of shining faces before you, there may be several who are already deeply into astronomy. So deeply, in fact, that one or two might yield to an uncontrollable compulsion to discourse loud and long on the mass-luminosity relationship of Alpha Canis Majoris, or some equally esoteric topic.

Such exuberance is fine at the right time and place; however, don't lose sight of the purpose of the initial meeting. A mystifying astro-vocabulary laced with strange terms and numbers can overwhelm a neophyte observer, and might even extinguish the desire to attend future meetings. Be prepared to gently but firmly steer the gathering back onto its organizational track. You can be sure many interested but silent beginners will thank you for it.

During your first meeting, open up



the floor to suggestions for programs. You should get plenty: slide shows, films, video tape shows, guest speakers, question-and-answer sessions. Whatever programs you agree on, try to generate a desire in everyone to return for future meetings. This is vital during the first two or three meetings.

A good way to sustain interest is to organize a star party as soon as possible. Don't scare people off by making them think telescopes are required. Instead, devote an evening to locating and identifying the season's major constellations, prominent planets, and other timely celestial attractions. And why not step outside for a half hour or so during your first meeting if it's a clear night. Also, when you're organized enough to know you'll have a good sized group at your star party, it's time to contact the TV stations again. Call about two days ahead of time and ask for the assignment editor — he'll ask you for details and most likely put a reporter on the story.

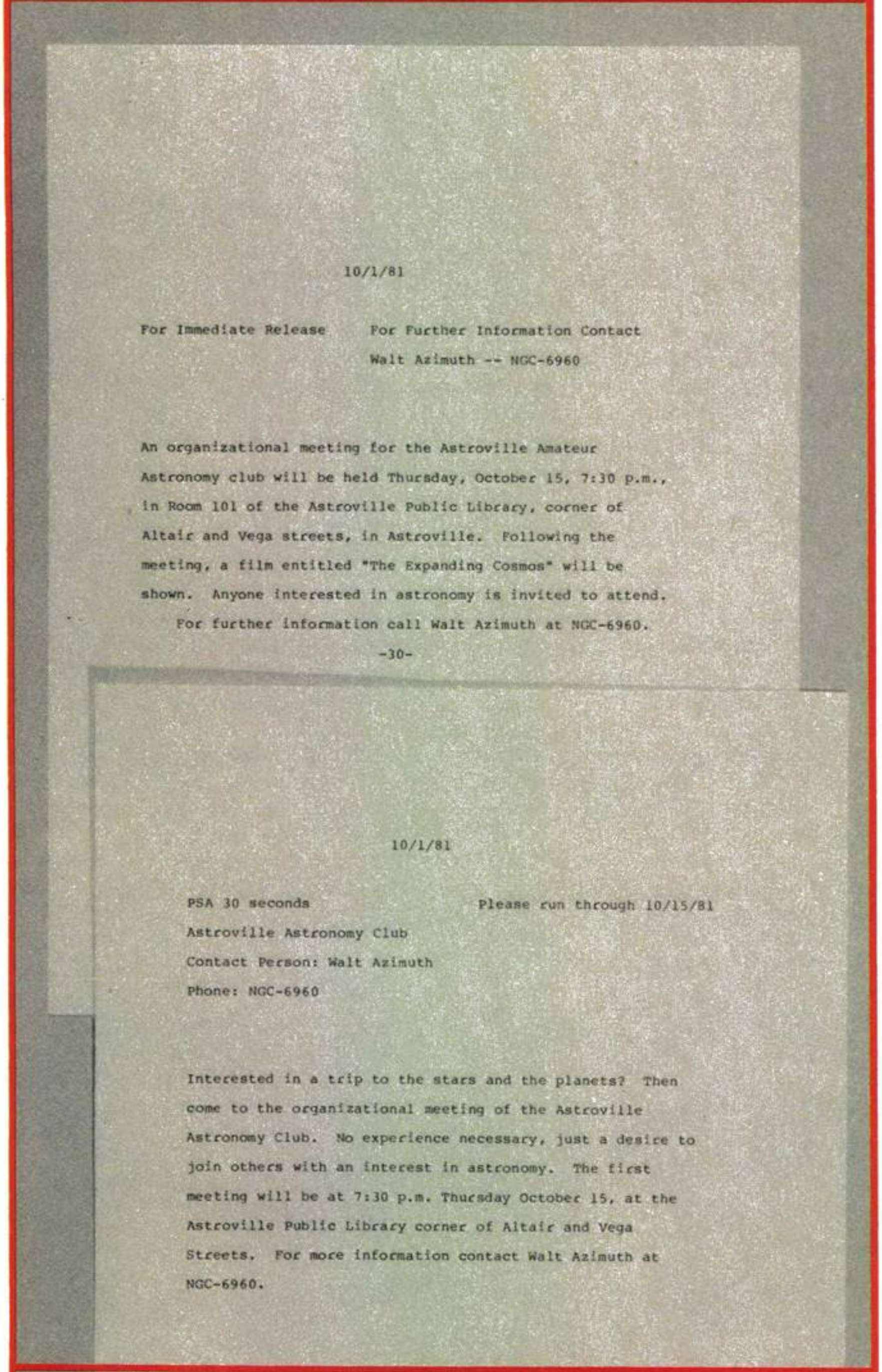
Discussion with members may eventually lead to annual dues and money-raising projects. Fortunately, it isn't expensive to keep a young astronomy club going since basic costs will be for postage and stationery. Incidentally, club membership entitles you and your fellow members to ASTRONOMY subscriptions at a discount. Once the club is off the ground, contact Stephanie Kiel (414) 276-2689 for details.

Well, your first meeting has concluded. The small groups of people who were talking animatedly have broken up, and nearly everyone has gone. You have names and addresses of all who attended, everyone knows where and when the next meeting is scheduled, and your astronomy club has been hatched. You worked hard, but it paid off.

After you have checked the room for lost articles and litter, you can leave with a sense of satisfaction, and maybe even a little amazement that so many people are, like yourself, interested in our astonishing universe.

And it is gratifying to know that you are no longer alone in your interest in the cosmos and its aesthetic and philosophical implications. It's a good bet that you and many others can hardly wait for the next meeting!

## spreading the word



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For Immediate Release — For Further Information Contact
Walt Azimuth -- NGC-6960

An organizational meeting for the Astroville Amateur Astronomy club will be held Thursday, October 15, 7:30 p.m., in Room 101 of the Astroville Public Library, corner of Altair and Vega streets, in Astroville. Following the meeting, a film entitled "The Expanding Cosmos" will be shown. Anyone interested in astronomy is invited to attend.

For further information call Walt Azimuth at NGC-6960.

-30-

10/1/81

PSA 30 seconds — Please run through 10/15/81
Astroville Astronomy Club
Contact Person: Walt Azimuth
Phone: NGC-6960

Interested in a trip to the stars and the planets? Then come to the organizational meeting of the Astroville Astronomy Club. No experience necessary, just a desire to join others with an interest in astronomy. The first meeting will be at 7:30 p.m. Thursday October 15, at the Astroville Public Library corner of Altair and Vega Streets. For more information contact Walt Azimuth at NGC-6960.

**Press releases should give the facts about your meeting in a straightforward manner and be routed to the city editor at newspapers, and the news directors of TV and radio stations.**

**Public service announcements can be a little more bouncy. They also have a good chance of being read verbatim on the air if you keep their reading time to precisely 30 seconds. Read them out loud slowly to time them, and send them to the public affairs director of the local stations. Don't be shy about this; radio and TV stations both are mandated by federal law to run a certain amount of public service announcements. Yours will very likely be one of them.**

**Type press releases and public service announcements double-spaced on 8½" x 11" white paper.**

---

*Gail Clark is a co-founder of the Pocatello (Idaho) Astronomical Society, a two-year-old club that is 25 members strong and growing. Besides his membership duties, Mr. Clark is Book Review Editor of the Reflector, the newsletter of the Astronomical League. He has been an observer for over four years and spends most of his telescope time viewing galactic and globular clusters.*

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More amateurs, professionals, schools and colleges have bought it, used it, recommended it and endorsed it than any other kind. It has been proven in use far beyond any other.

Recognition of the RV-6 among schools, colleges, professionals and expert amateur astronomers is beyond question. No other instrument of its kind has been more proved in use or more widely praised and enthusiastically accepted. Thousands upon thousands of RV-6 Dynascopes prove our engineering leadership. Certainly, more 6" Dynascopes are in use throughout the world today than any other competing model.

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photography
in
astronomy

# mr. scrooge in the darkroom; or, how to save $ in astrophotography

by
**Michael Covington**

It's no secret that photography is expensive. Silver, a precious metal, plays a vital role in the process, and the cost of all photography supplies and services — film, paper, developing — rises right in line with the rate of inflation. But take heart, there are some steps you can take to counter those soaring costs.

To hold down the expense of photography, you should follow these three basic principles: Buy low, prevent waste, and avoid unnecessary costs. Let's take a look at some ways to apply these principles in practice.

### Buy Low

Never pay list price for film, photographic paper, or prepaid processing mailers. Each of these is available at a discount if you know where to look.

In general, camera stores fall into two classes: those that charge full list price and those that sell almost everything at a discount. Often, the only way to tell the difference is to examine prices. But if you happen into one of the full-list-price camera stores, ask for a student and/or cash discount; many camera stores feature these, especially on large purchases.

Usually the lowest film prices in town are not found in camera shops, but in large discount stores that sell in high volume. You can also save by scanning the ads in the back pages of any major photography magazine and shopping by mail. But don't let shipping and handling charges on small orders exceed what you would save.

Keep your eyes open for special offers — you can often save even more. For example, the list price of a 36-exposure roll of 35 mm Agfachrome 64, with processing included, is $9.25. The camera store I regularly shop at normally sells this for $7.49, a 19% markdown, but once they had it on special for $5.99. At the same time, Agfa was running a $1 rebate offer, so I got it for a net price of $4.99 — a total discount of 46% off the price list! Remember, the competition among suppliers is fierce — and they all want your business. Always shop around.

Kodak film is generally the most expensive brand. For instance, one New York dealer's advertised prices for 36-exposure rolls of various 35 mm color slide films (with manufacturer's processing included) stack up as follows: Agfachrome 64, $4.39; Fujichrome 100, $5.19; Kodachrome 64, $6.69; Ektachrome 200, $8.39. Off-brand films such as K-Mart or Sears can be very cheap but, in my experience, they are inferior to name brands in color rendition and graininess.

Out-of-date film can also extend your buying power. Generally, black-and-white film stored in air-conditioned buildings is good for a few years after its expiration date — although it may lose a bit of speed and contrast.

Color film probably should not be trusted more than six months after expiration, unless it has been under constant refrigeration. Of course, you can store film and paper in your own refrigerator for practically unlimited periods of time. But don't allow moisture to condense on the materials when you take them out of the refrigerator. Keep them in airtight containers, and leave them sealed until they warm up.

Another way to cut film costs to the minimum is to buy film in 50 or 100-foot rolls and bulk-load it. A good bulk-loader costs between $12 and $20, and makes it possible to spool any length of film you want into 35 mm cassettes in ordinary room light.

A 50-foot roll of Tri-X costs $11.70 and makes at least nine 36-exposure rolls. This works out to $1.30 per roll ($1.80 if you don't do your own darkroom work and can't reuse the cassettes). Ready-made 36-exposure rolls list for about $3 each, and the best New York discount price is still around $2 per roll (in large quantities).

One word of caution: some bulk-loaders pass the film through a plush velvet light trap that can catch grains of dirt which will scratch the film. I have had problems with this in stellar photography, where high-contrast printing and a smooth sky background bring out scratches that would be invisible in pictorial photographs. The Watson bulk-loader overcomes this by using a different kind of light trap in which the film doesn't touch anything.

To save even more, you can also buy your photographic paper and chemicals in bulk. The cost of paper drops by nearly half if you buy the 100-sheet boxes instead of 25-sheet packs. As for chemicals, liquid concentrates such as Ilford Ilfosol film developer, Kodak Versatol print developer, and Kodafix solution keep practically forever in undiluted form and can be prepared in small quantities as needed.

Kodak does not, however, recommend mixing less than the entire bottle of HC-110 developer concentrate at a time; they hold that the syrupy liquid canot be measured accurately. But with a plastic hypodermic syringe, you can accurately measure and transfer 2 to 20 ml of HC-110 for quick and accurate dilution.

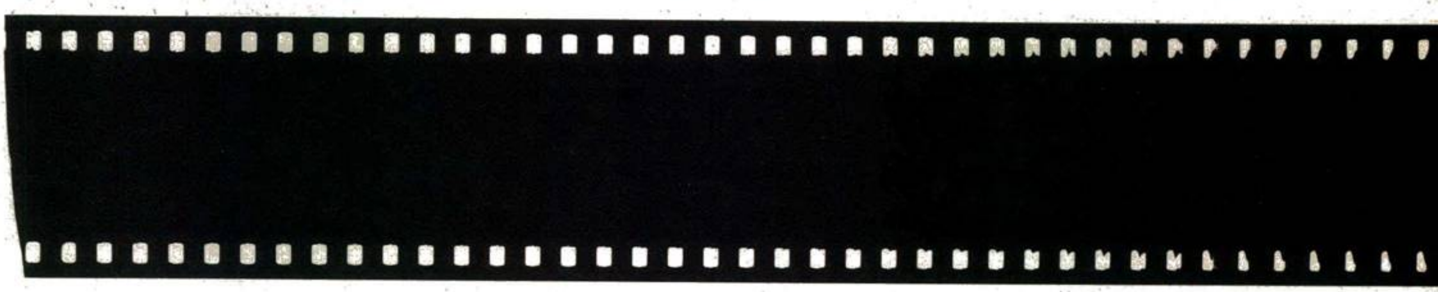
Also, many manufacturers do not recommend dividing up packets of solution mix-powder, since the contents may have become unevenly mixed during shipping. If you want to try this, though, shake the packet or can thoroughly before opening it, measure by weight rather than volume, and seal the unused portions in airtight containers.

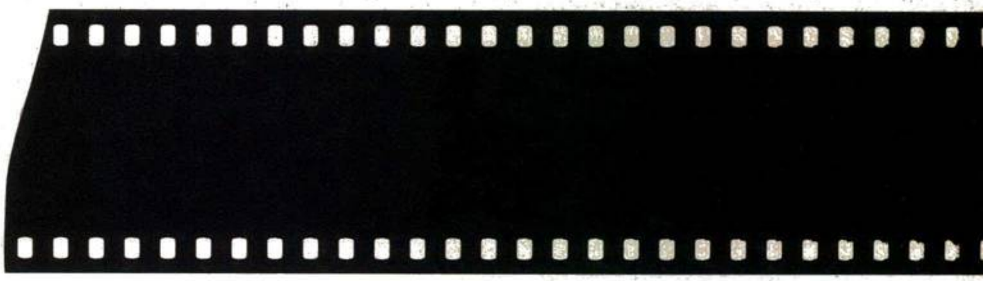
### Prevent Waste

First, and most obviously, don't take pictures you know won't come out well. There's no point in trying high-resolution planetary photography if the air isn't steady, or in photographing the Veil Nebula through haze.

You can save film by writing down exposure information so you don't have to run through the full range each time. When you bracket exposures, use 2-stop rather than 1-stop intervals (that is, change exposures by a factor of 4 rather than 2). If you've tried 1/1000, 1/250, and 1/60 second, then there's not much point in trying 1/500 or 1/125, except on the very highest contrast films.

Go for versatility in your choice of film, paper, and chemicals. Tri-X and HP5 are excellent black-and-white films, though if your specialty is planetary photography and you never photograph deep-sky objects or star fields, Plus-X or FP4 may be a better choice. Ilford's Microphen developer is particularly useful because it yields moderately fine grain with extreme push-processing — you can push HP5 to an effective exposure index of 3200 — and it can also be used as a fine-grain developer for souping film at normal speed. For color, Ektachrome 400 is an excellent all-round film, though somewhat expensive.





Another money-saving technique is to test new methods, lenses, and the like with off-brand or out-of-date film in order to find and eliminate technical problems before using more expensive materials. It would be a real waste to go through an entire roll of 103a-F — about $10 — only to discover that the lens you were using wasn't sharp enough at the edges, or that your guiding technique was so wretched that star images look like migrating geese.

If the majority of your photos consist of tiny planet images on 35 mm film, you may want to scout out the discontinued Olympus Pen F camera body. This camera uses a half-frame (18 x 24mm) format, and will allow you to pack twice the usual number of exposures onto a roll. Another way to squeeze more planet images onto a roll is to multiple-expose in two, three, or four different positions on each frame.

### Avoid Unnecessary Costs

Occasionally, something that seems economical at first turns out to be a prodigious waste of money. For example, I was recently toying with the idea of doing my own gas-hypersensitizing. When I worked out the economics of it, though, I found that in order to save money by treating my own film instead of buying it already hypersensitized, I would have to go through at least twenty 36-exposure rolls — a total of over 700 exposures! In my entire life I have taken only about four hundred astronomical photographs. It was obvious I didn't need the hypersensitization equipment, though it would still be a good buy for a small observatory, a club, or other high-volume users.

Another expense, often unnecessary, is exotic special processing of film. Although it's a good idea to push-process stellar photographs for maximum speed, don't take the search for a magic elixir to excessive lengths. Off-the-shelf developers such as Microphen, D-19, and Diafine work perfectly well.

What counts in stellar photography is the film's response to minimum exposure; the choice of developer can alter this only slightly. Push-processing sharply increases the film's response to mid-range tones, but has relatively little effect on faint images of nebulae. In fact, many of Evered Kreimer's fine pictures in *The Messier Album* were intentionally underdeveloped to produce better tone gradation — so contrast isn't everything.

Even push-processing Ektachrome 400 to E.I. 800 won't greatly improve your prints or slides. In one test, the speed gain for 5-minute exposures was slight — around 40% — and the unpushed film actually showed more stars, presumably because grain was finer.

### Where Not to Skimp

Remember, despite the money-saving advantages outlined here, across-the-board cost-cutting isn't always a good idea. First, and foremost, don't ever let a concern for economy keep you from taking that once-in-a-lifetime picture. When conditions are truly exceptional, make the most of them. If you are photographing a rare phenomenon, forget the cost and shoot as much as you have to — you may never get the chance again.

Second, don't skimp on the original processing of the film. In black-and-white, I prefer "one-shot" chemicals — then I know I'm not risking developer or fixer exhaustion. With color slides, I always have my film developed by the manufacturer. Corner-drugstore labs have on various occasions mounted my slides backwards, cut them apart wrong, and even burned a hole in a negative.

Finally, don't neglect presentation and display. Far too many good astronomical photographs languish in file boxes or notebooks instead of being displayed where we and our friends can see them. If you don't want to frame them, then at least matt them. If you have never done this before, take a print to a "u-frame-it" shop and you'll see how easy it is.

If you have a darkroom, you can make color prints from slides yourself (using Cibachrome or a similar process) — or you can go to a custom lab. In any case, many people find the price of prints is well worth paying in terms of lasting enjoyment.

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*Michael Covington is finishing a Ph.D. in theoretical linguistics at Yale; he spends vacations gazing at nebulae and galaxies from his native Georgia. He has been an astrophotographer for over 12 years.*

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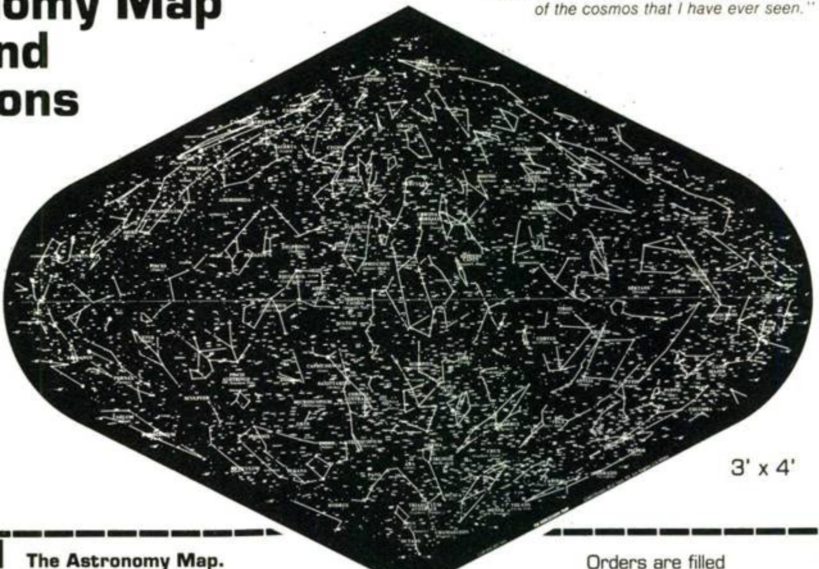

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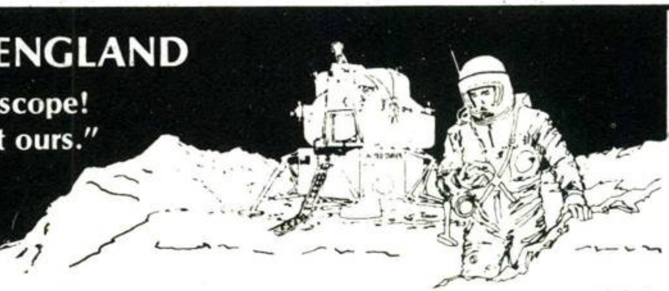

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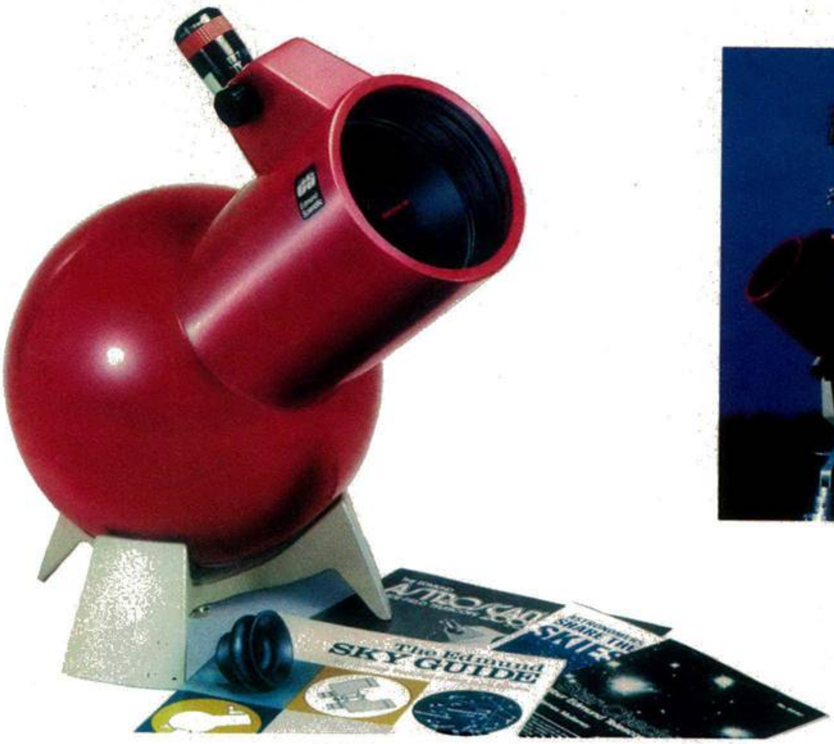

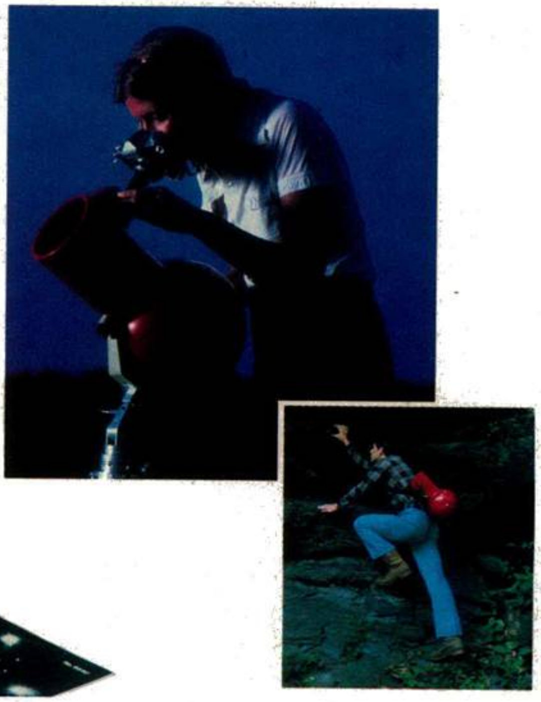

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On examining the C90 you’ll be amazed at the compactness, light weight and high quality of workmanship. Here is a 1000mm telephoto lens that gives the naturalist/astronomer/photographer tremendous versatility and all in an optical tube assembly that weighs less than 3½ pounds and is only 8 inches long.

THE C90 ASTRO TELESCOPE

**What Can You See With a C90**

As a daytime telescope, the C90 is remarkably powerful. With it you’ll see details on bees buzzing in flowers 20 feet away and recognize faces of friends at ½ mile. At night, there are countless wonders in a dark sky visible through the C90. The Moon will display a multitude of craters, rugged mountains, rills, and smooth plains (the lunar seas or maria). Other planetary companions in the solar system are readily available for your close scrutiny. You’ll see Jupiter’s cloud belts and the great red spot. The four large moons of Jupiter, the Galilean satellites, are easily seen as they race around the giant planet in endless cycles governed by the laws of celestial mechanics. The rings of Saturn are easily visible, too. Under dark skies, away from the lights and pollution of large cities you’ll be able to see countless galaxies, star clusters and sites where stars are being born or have recently died. Countless details of the cosmos are revealed for your inspection!

**Extensive Line of Accessories for Photography/Visual Use**

The Celestron 90 offers the most extensive array of accessories for visual and photographic use of any instrument of its type. For photography, convenient adaptors (optional) attach your 35mm SLR camera body to any of the C90’s. This permits telephoto photography, long distance macrophotography (the close focus is about 10 feet), full disk lunar or solar photography and planetary photography.

Considering Celestron’s optical quality, unexcelled reputation for excellence, total quality control, extensive accessory line, full warranty, and moderate cost versus the continually rising prices of poor quality imported telescopes and the very high prices of some domestic catadioptrics, the C90 is perhaps the best telescope buy in the world and an ideal choice for the beginning amateur astronomer, nature enthusiast or photo hobbyist.

# Maksutov-Cassegrain System

# • C90 Astro Telescope

Multipurpose Instrument

## 3 Versions of this Ultracompact system are available

### The C90 Astro Telescope

This unit is supplied with a single-tine fork mount and electric clock drive with setting circles. This version is well-suited to lunar and planetary observing and photography, binary stars, star clusters, and nebula studies. The C90 Astro can still, with the proper accessories, be used as a terrestrial spotting scope or as a telephoto. The optical tube assembly readily demounts from the fork mount and still has a photo tripod adaptor to mount on a conventional photographic tripod.

The base price of the C90 Astro telescope includes the complete working telescope, the optical tube assembly, 5x24 finder-scope, star diagonal, 18mm ocular, 2.5x Barlow lens, photo tripod adaptor, fork mount, setting circles, manual slow-motions, electric clock drive, clock drive cord, lens cap, carrying case and instruction manual. Optional accessories are described in our catalog and are listed under the C90 section of the leaflet, "Celestron List Prices." Instructions on the use of the optional accessories and the standard features can be found in the instruction manual.

### The C90 Spotting Scope

This instrument is the same unit as the Astro Telescope but does not include the fork mount, electric clock drive mechanism, slow-motion controls and setting circles. It is provided with a photographic tripod adaptor so that you can mount it on any standard photographic tripod or the *Celestron photo tripod.* It can be used for astronomy, terrestrial viewing and telephoto photography. The C90 Spotting Scope is all you need if you only occasionally wish to pursue astronomical observations. It will show as much as the Astro Telescope and you can add the fork mount and drive at a later date.

The base price includes the optical tube assembly, 5x24 finderscope, star diagonal, 18mm ocular, 2.5x Barlow lens, photo tripod adaptor, lens cap, carrying case and instruction manual.

### The C90 Telephoto Lens

The same diffraction limited optics found in the C90 Astro and Spotting Scopes are incorporated in the Celestron C90 Telephoto Lens. This unit is finished in a rich textured black color for compatibility with other camera accessories rather than the traditional orange and brown of the standard Celestron line. The folded mirror lens optical system gives photographers a 20x (1000mm focal length) telephoto that is super compact with razor-sharp images that are achromatic. Yet with the addition of an eyepiece and either a Porro Prism (for terrestrial use) or star diagonal (for astronomical use) you have the same powerful telescope as the other versions of the C90, minus the finderscope and the fork mount.

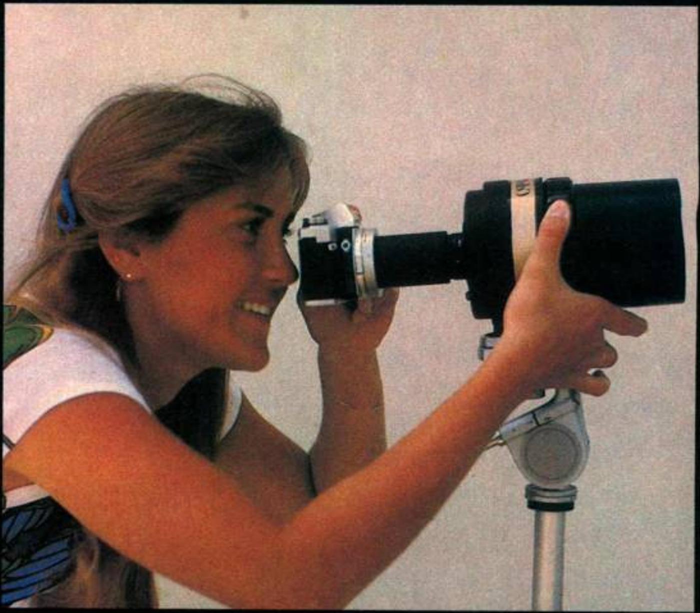
Base price includes lens, T-Adaptor, Photo Tripod Adaptor, lens cap, carrying case and instruction manual. Ready to mount on a photographic tripod. Ready for telephotography with the addition of T-ring and 35mm SLR body. Note that this version of the C90 cannot be adapted to a fork mount, nor is a separate finderscope available.

**BASIC C90 SPECIFICATIONS**

| | |
|---|---|
| Optical configuration | Maksutov-Cassegrain |
| Clear aperture | 3.55 in. (90mm) |
| Effective focal length | 40 in. (1000mm) |
| Photographic speed (focal ratio) | f/11 |
| Highest useful visual magnification | 210x |
| Near focus (approx.) | 10 ft. (3m) |
| Resolution: | |
| Arc seconds (Dawes' limit) | 1.3 |
| Stellar magnitude limit | 12 |
| Image scale — degrees per inch | 1.43 |
| Film coverage (on 35mm format) at: | |
| 30 feet | 1 x 0.7 ft. (30 x 20cm) |
| 100 feet | 3.4 x 2.2 ft. (100 x 67cm) |
| 1000 feet | 34 x 22 ft. (10 x 6.7m) |
| Secondary obstruction | 15% (1⅜ in. dia.) |
| Telephoto/Spotting Scope | |
| Tube dimensions | 5 in. (13cm) dia., 8 in. (20cm) long |
| Tube weight | 3 lbs. (1.4 Kg.) |
| Astro telescope size, swung down | 7 x 7 x 13 in. |
| Astro telescope weight — complete | 8 lbs. (3.6 Kg.) |
| Shipping weight: | |
| Telephoto/Spotting scope | 8 lbs. (3.6 Kg.) |
| Astro telescope | 17 lbs. (7.7 Kg.) |

SEE OPERATING MANUAL FOR COMPLETE SPECIFICATIONS.

The C90 Telephoto



The C90 Spotting Scope

SEE BACK COVER FOR CATALOG INFORMATION

# AstroNews

## STS-2 Flight Being Readied by NASA

Preparing the Space Shuttle *Columbia* for its second flight has taken NASA engineers and technicians a little longer than planned, though as we go to press in early August, the September 30 launch date remains firm.

Shipped to the Kennedy Space Center at Cape Canaveral, Florida, from its landing site at Edwards Air Force Base, California, *Columbia* made the trip riding piggy-back on its modified jumbo-jet carrier.

On its arrival, technicians spent about two weeks inspecting and correcting minor malfunctions that cropped up on the first flight — including a jammed toilet and a balky power unit that were replaced.

The Shuttle's three main engines were thoroughly inspected without being removed from the spacecraft and they checked out perfectly. Engineers removed the engines' fuel pumps for a close examination; the pumps were then re-installed because they showed no sign of problems.

About 350 tiles needed replacement; some 800 more were removed, "densified" for better adhesion, and re-attached; an additional 2,000 needed minor repairs. In the cockpit area, some of the electronics were pulled out and shipped back to manufacturers for performance tests. Engineers checked the landing gear and replaced the wheels on the two main gear struts.

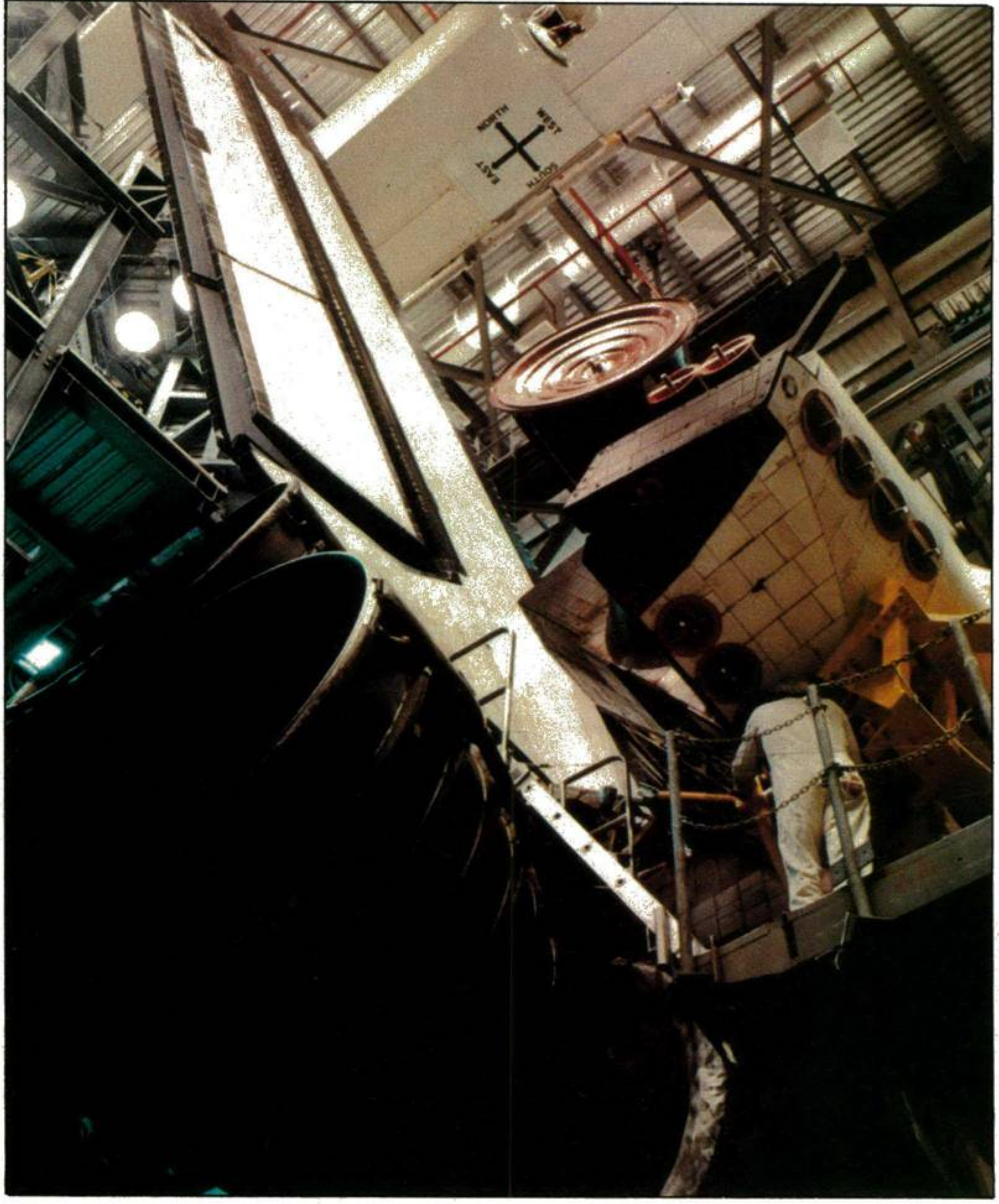
The blast of the solid-fuel boosters at lift-off created more stress on the spacecraft and launcher assemblies than designers had calculated. Damage that was done to struts holding the forward reaction control system fuel tanks aboard the Shuttle has been repaired. The launch pad itself needed to have new ablative material applied to the holddown posts that support and restrain the Shuttle before lift-off. And to help control the problems on future launches, much more water will be sprayed into the boosters' exhaust and over the mobile transporter — which took a beating from the solid-fuel boosters.

The second flight will carry a payload — the OSTA-1 (Office of Scientifical and Technical Applications) package. (See AstroNews for August, page 62.) To deploy this and other payloads in orbit (and retrieve them), *Columbia* will carry a newly-installed 50-foot cargo boom, the Remote Manipulator Arm.

When the payload is securely placed in *Columbia's* cargo bay, its doors are sealed for flight. Technicians then roll the Shuttle a short distance from its hangar to the Vehicle Assembly Building (VAB) where the intricate process of attaching the external fuel tank and boosters takes place.

After three weeks of tests in the VAB, the fully-assembled Shuttle rolls out on its transporter/launcher to Pad

*In this view looking up at the Shuttle's tail, we see a technician working on removing one of the Orbital Maneuvering System pods. NASA photo.*



39A. About five weeks more of tests and practice countdowns precede the real thing.

The mission plan calls for launch on September 30, during either of the two launch windows: 8 a.m. EDT to 11:53 a.m. EDT, or 12:18 p.m. EDT to 1:56 p.m. EDT.

Currently, NASA is planning a 124 hour, 55 minute mission (5 days, 4 hours, 55 minutes) with 83 orbits. The craft will touch down at Edwards Air Force Base on October 5 at 9:55 a.m. PDT during the 84th orbit.

The crew for the second Shuttle flight will be commander Joe Engle and pilot Richard Truly.

## Satellite Helps Airliners Avoid Ozone Concentrations

Initial results from a test that examined weather satellite data could help airliners avoid heavy concentrations of atmospheric ozone.

The two-month experiment, begun last March, was conducted jointly by NASA, the Federal Aviation Administration, the National Center for Atmospheric Research, and Northwest Airlines.

In the test, data from an instrument aboard the Nimbus-7 spacecraft were transmitted to NASA scientists at Goddard Space Flight Center. They processed and relayed the resulting information within three hours to Northwest Airlines meteorologists in Minnesota for use in weather forecasts.

Early analysis shows that the ozone detected by the satellite accurately traces upper air patterns and can be used to locate weather features such as through lines and fast-moving fronts. Clear air turbulence, which can injure passengers and damage aircraft, is associated with such fronts. If weather forecasters can locate the fronts ahead of time, aircraft can avoid them.

Because instruments flown on research aircraft detected large amounts of ozone in areas where the satellite instrument "saw" high concentrations of it, routine forecasting of high concentrations of ozone may now be possible. This could help pilots avoid high concentrations where ozone can enter an aircraft through its pressurization system and cause shortness of breath as well as eye, nose, and throat irritation in some passengers and crew members.

## League Publishes List of Herschel Deep-Sky Objects

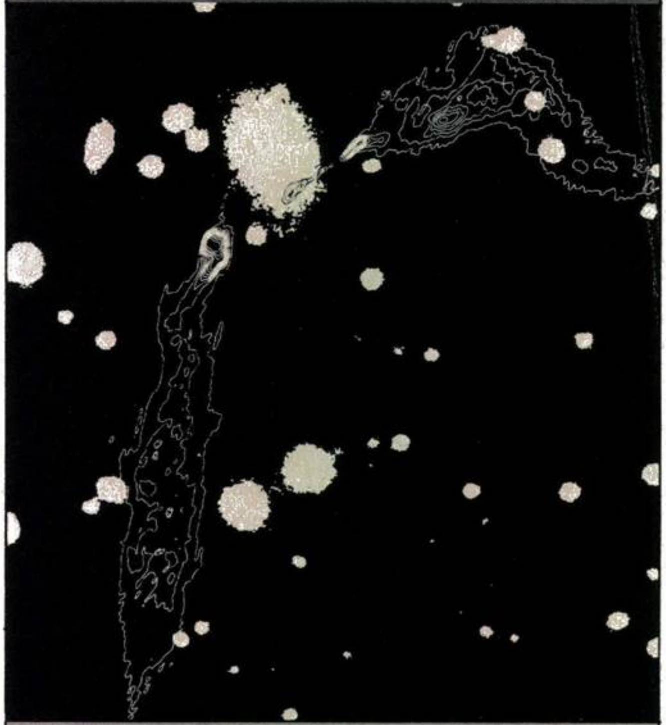
Two new educational programs have been announced by the Astronomical League.

The Herschel Club, conducted by the Ancient City Astronomy Club in St. Augustine, Florida has been developed as an advanced sequel to the popular Messier Club deep-sky observing program. Observers who have viewed 400 selected objects originally cataloged by William Herschel in the 18th and 19th centuries will be eligible for specially-designed league certificates that acknowledge their work.

A committee of the Florida group led by Brenda Guzman has been working on the project for two years. Detailed descriptions and photographs of each of the 400 objects will be published in an observing guide similar to the League's present *Observe the Messier Objects*. Records of estimated magnitude, sky conditions, type of instrument used, time and description of the particular object are verified by a local society officer or forwarded directly to Guzman for verification. Any telescope owner may participate. For more information, write:

Ancient City Astronomy Club,
495 Arricola Ave.
St. Augustine, FL 32084

## Radio Eyes See Different Galaxy



*UNUSUAL VIEW — If a person could see radio waves as well as visible light, this is how the radio galaxy 3C465 would look. New Mexico Institute of Mining and Technology astronomer Jean A. Eilek, in collaboration with astronomers Jack Burns of the University of New Mexico and Frazer Owen of the Very Large Array, is investigating the galaxy using optical and radio studies of the galaxy itself and X-ray recordings of the intergalactic gases surrounding it. The wavy lines in the photograph represent the radio signals emitted by hot gases in the galaxy's "wing-like structures" as they were recorded at the Very Large Array in New Mexico. The white spot in the center is an optical view of the stellar portion of the galaxy. The other white spots are stars and companion galaxies as seen from the Palomar Observatory in California. (Photo copyrighted by the National Geographic Society-Palomar Observatory Sky Survey and reproduced by permission.)*

## Scholarly Paper Publishing Up 700% Since 1910

The number of scientific papers published each year in all fields has increased greatly since the turn of the century — and astronomy is no exception. Recently, astronomer

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- New Radio Scope for Cerro Tololo
- IRAS Continues to Progress
- Tarantula: Why Does it Shine?

# AstroNews

Helmut Abt of Kitt Peak National Observatory analyzed some of the periodical literature of astronomy and came up with some interesting comparisons.

Abt used three American journals that have been published from 1910 to the present: *Astrophysical Journal, Astronomical Journal,* and the *Publications of the Astronomical Society of the Pacific.* These three have published about 60% of all U.S. astronomical papers, and cross checking showed that they make a representative sample.

Abt found that the number of papers published each year increased tenfold between 1910 and 1980. In the same period the average length of each paper grew from 2.7 pages to 8.7. In 1910, 42% of all papers published were less than a page long; today, one-pagers have essentially disappeared (0.4%). In 1910, papers had an average of 1.1 authors each; now the average is 2.4. Scientists, it seems, are writing fewer, but longer, papers.

One paper in 20 was of a theoretical nature in 1910, but by 1980 one out of every three was. In 1910, every theoretical paper had a single author; now only 41% of them do. With observational papers, the "single-author" fraction has dropped from 89% to 26%. Today the average theoretical paper has two authors; the average observational, three.

A look at the trends decade by decade shows that total number of papers published each year stayed relatively constant until the 1940s. From then through the 1970s there was a logarithmic increase, doubling every 7.8 years. Since the '70s, this upward slope appears to be flattening out slightly.

The surge probably reflects the new instruments and techniques — as well as substantial government funding — that followed WW II. The recent slowing-growth trend may be a result of the budget cutbacks which began in the late '60s, or perhaps the simultaneous appearance of more and specialized publications — *Icarus,* for example. These may have siphoned off papers that earlier would have appeared in one of the three journals studied.

Where did Abt publish his study? In the June/July 1981 *Publications of the Astronomical Society of the Pacific.*

## Puzzling Meteorites Found: May Be from Martian Surface

Scientists studying two unusual meteorites found in Antarctica have reported that the extraterrestrial objects are extremely young in geologic terms and have speculated that they may have originated when a large meteorite crashed into Mars and tore them loose from the planet's surface.

The meteorites, named shergottites for the city in India where the first one was found in the 1800s, appear to have crystalized from lava no more than 1.2 billion years ago. Almost all other meteorites are about 4.5 billion years old, and are believed to have originated at the time the solar system was formed.

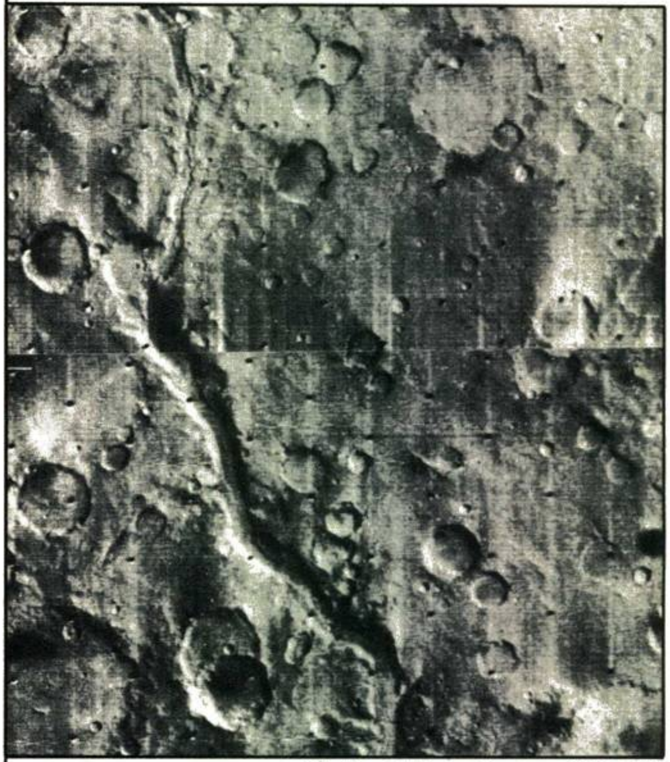
If the two Antarctic meteorites did originate on Mars, researchers will be able to learn much more about the origin and evolution of the solar system's planets.

The two meteorites were found during expeditions headed by Dr. William A. Cassidy of the University of Pittsburgh. Ages of three of the four shergottites were determined by Dr. Lawrence E. Nyquist of the Johnson Space Center in Houston through a technique using the radioactive decay of certain isotopes of samarium and rubidium; a similar study of the fourth meteorite is underway.

The young meteorites puzzled scientists because they are of igneous origin — formed from volcanic action or by an intense heating process.

John O. Annexstad of NASA said scientists believe they are seeing matter from Mars because that planet is known to be volcanically active and because there is no current explanation as to how rocks from the asteroidal belt, between Mars and Jupiter, could have generated heat enough to create igneous material so late in the solar system's history.

Mars was chosen as the most likely candidate not only because it is known to have had volcanic activity, but also because planetary scientists believe that activity occurred at or about the same time as the creation of the shergotties. Moreover, Mars is much less massive than Venus and thus chunks of rock could escape far more easily from its gravitational pull.



*Mariner 9 Photo Courtesy NASA/JPL*

## Cerro Tololo to Get New 1.2 Meter Radio Scope

For eight years now, a 1.2-meter radio telescope designed and built by Columbia University scientists has been operating atop a building on Columbia's New York City campus, charting the immense clouds of interstellar gas that dot the Milky Way. It soon will have a twin — this one astride the Andes Mountains in Chile.

The National Science Foundation recently announced a program to install a duplicate of Columbia's instrument at the Cerro Tololo Inter-American Observatory, 60 miles east of the seacoast town of La Serena, Chile.

The new telescope will be operated 24 hours a day by scientists from Columbia university, the Goddard Institute for Space Studies, the University of Chile, and the Cerro Tololo Observatory. It is now under construction in Columbia's Pupin Physics Laboratories building under the supervision of the same team that built the original in 1973 — physicists Patrick Thaddeus and Richard S. Cohen.

According to Dr. Cohen, "The size of a radio telescope is proportional to the wavelength at which it works. Our telescope hears radio waves with a length of 2.6 millimeters. That gives it the same resolving power as a 300-foot instrument which would operate at a longer wavelength." The Columbia telescope has a dish only four feet in diameter, and because the 2.6-millimeter wavelength is not in commercial use, there is no background noise even in the heart of Manhattan.

Dr. Thaddeus says, "At such very short wavelengths, New York is as quiet as the day Henry Hudson came sailing up the river: civilization doesn't make a racket."

When the Chilean telescope goes into operation next year, it is expected to help produce the most complete map yet of interstellar molecular hydrogen.

## Major International Space Telescope Being Prepared

The IRAS (Infrared Astronomical Satellite), a highly sensitive infrared telescope that will make the first comprehensive infrared survey of the entire sky, has been mated to its Dutch-built spacecraft in the Netherlands. The craft will map perhaps a million infrared sources, many of them previously unknown. The results of this survey could change our concept of the universe, because infrared light from the stars and other cosmic sources is blocked out by the Earth's atmosphere.

The telescope will see those numerous sources for the first time. The instrument was built for NASA's Office of Space Science by Ball Aerospace Systems Division, Boulder, Colorado, and its development has been managed by NASA's Ames Research Center, Moffett Field, California. The project is an international joint venture of the United States, the Netherlands, and the United Kingdom. Project management in the U.S. is at the Jet Propulsion Laboratory, Pasadena, California. The telescope is scheduled for launch in August 1982.

Sky surveys have been a longtime tool of astronomers, providing basic information from which the more complex aspects of the character and evolution of the universe can be studied. The IRAS telescope is expected to provide a wealth of information about astronomical sources, including new and unusual kinds of stars, and perhaps entire infrared galaxies. It should locate thousands of new quasars whose light is 11-12 billion years old and comes from the early universe. Hence, IRAS could provide new generalized evidence about the "Big Bang" theory and formation of the universe.

This new telescope in space may find that a far larger part than expected of the universe's energy budget is in the infrared. IRAS will look into the dust-hidden center of our Milky Way with its possible black hole, and could locate new asteroids, invisible cool stars near the Earth, and even a suspected far outer planet.

Other areas for IRAS investigations are the processes of star formation and death, origin and replenishment of interstellar matter, and exploding and "star-manufacturing" galaxies.

More than half of the IRAS effort will go into producing the first high sensitivity infrared sky map and catalog. The rest of the year-long mission will be devoted to special studies. These might be detailed observations of an infrared galaxy, studies of clusters of galaxies, a "close-to-home" asteroid search that will survey the plane containing the Sun's planets, a possible outer planet search, and an attempt to find undiscovered comets. All of these "cool" objects are easier to detect in infrared.

The telescope employs highly advanced technology. Its focal plane will operate at a temperature just four degrees above absolute zero (-456° F). The plane will be cooled by extremely heat-conductive superfluid liquid helium — the first time this material will be used in space. The entire interior of the telescope will be cooled down to within 15° F above absolute zero. An array of 62 infrared detectors in the focal plane will measure infrared radiation in four wavelength bands, centered at 10, 20 50, and 100 micrometers.

To eliminate its own heat radiation that would interfere with its readings, the entire telescope is super-cooled. It is surrounded by a double-walled cylindrical vessel (a Dewar) filled with 70 kg of superfluid liquid helium. The use of special insulating materials and of construction with low-heat-conductive components will limit the effects of heat radiation from the Sun and Earth. An even temperature everywhere in the helium vessel is created automatically by the extreme heat conductivity of the helium.

A helium vessel of this size has never been used in space, but rocket flights have shown that a Dewar vessel will function under weightless conditions.

The IRAS telescope uses two-mirror Cassegrain-design optics. Infrared radiation from space falls first on the large, concave primary mirror. It is then reflected upward to the small, convex secondary mirror which reflects the radiation back down through the cylindrical aperture in the primary mirror and onto the 62 detectors in the focal plane. Also located at the focal plane is a spectrometer.

For maximum measuring accuracy, optical mirrors and detectors will be guarded against contamination. During tests on Earth, the instrument is kept tightly sealed because, with the whole system cooled to such a low temperature, any of the known gases except helium would condense and freeze on vital components. Contamination just 0.001 millimeter thick on the optics is enough to cause an incorrect measurement.

An onboard computer in the spacecraft will perform the IRAS mission, responding to instructions from Earth. Two solar panels will supply electrical power for satellite and telescope operations.

## Baby Stars' Light Key to Making Tarantula Shine

With its tendril-like filaments of gas and dust, the Large Magellanic Cloud's Tarantula Nebula is an awesome sight. But to astronomers, this nebula's aesthetic appeal is eclipsed by the spectacle of its physical properties — this is a stellar nursery, the most intrinsically luminous star-forming region among all the galaxies of the Local Group.

Inside the nebula, nearly at its center, is a bright region called R136a. This and other baby star sites are believed to light up the nebula as we see it with stars ionizing their surrounding placenta of mostly hydrogen gas. Perhaps up to 100 huge (150 times the mass of the Sun) and hot (40,000° Kelvin) stars emit the ionizing light. But a new study shows that the Nebula is almost entirely lit up by R136a, and that R136a contains only one star, the biggest and brightest ever seen.

Joseph Cassinelli, John Mathis, and Blair Savage, from the University of Wisconsin's Washburn Observatory, reported the discovery of this superstar in a recent issue of *Science*. They exploited a new trend in astronomy — observing with satellites — using the International Ultraviolet Explorer (IUE) satellite to study radiation in the ultraviolet end of the light spectrum at wavelengths hidden to ground-based observers by our opaque atmosphere. Hot atoms give off spectral lines in the UV, so they observed several UV spectral lines in R136a to find out what kind of environment exists. Turbulence and temperatures were inferred from the data, and the result: R136a is a very hot (60,000° Kelvin) region whose UV lines could not be explained by an aggregate of stars. The best explanation theorists have at present is a single, superhot star with the mass of 2500-4400 Suns.

The hottest and heaviest star known is a challenge to those trying to understand how it can exist. Previous stellar record holders were a "mere" 200 solar masses at about 50,000° Kelvin. At yet higher masses and temperatures, gravity and light pressure battle for control of a star in a futile fight that, according to previous thinking, would blow a star to pieces. Cassinelli and his colleagues believe that R136a has come to a fragile equilibrium of the two opposing forces, with an intense stellar wind mediating the two. But even so, R136a pays the price — it loses up to one solar mass of material every 5,000 years — a fleeting moment in the life of a normal star.

Why don't superstars exist in the Milky Way? One possibility is that dusty environments prevent the formation of heavy stars (the Milky Way is much dustier than the Large Magellanic Cloud). In this case, other leviathan stars may be present in "cleaner" galaxies; all we have to do is find them. *N.L. Cohen.*

37° 31′ 33″ N

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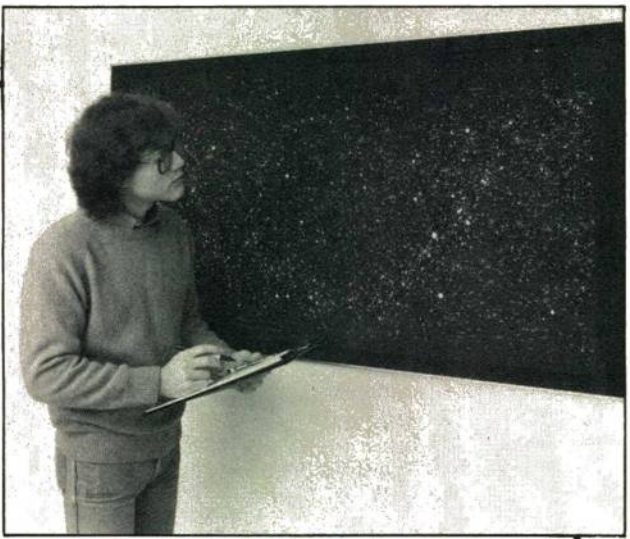

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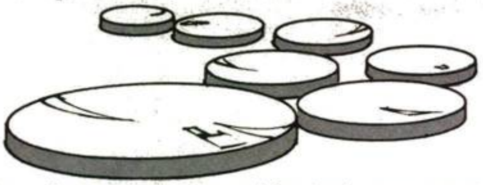

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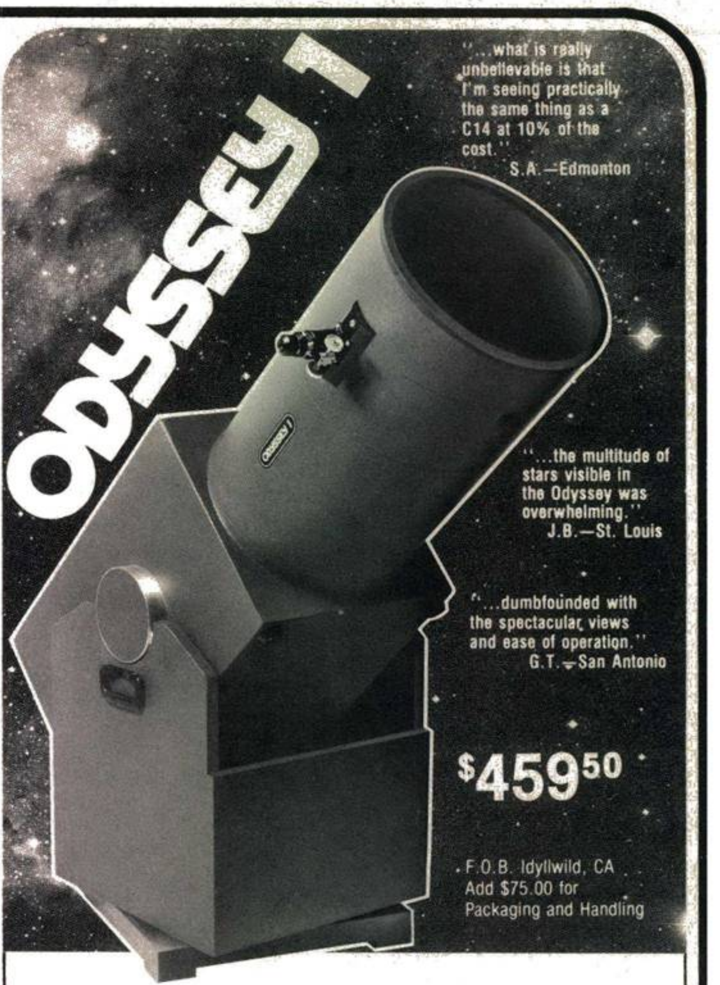

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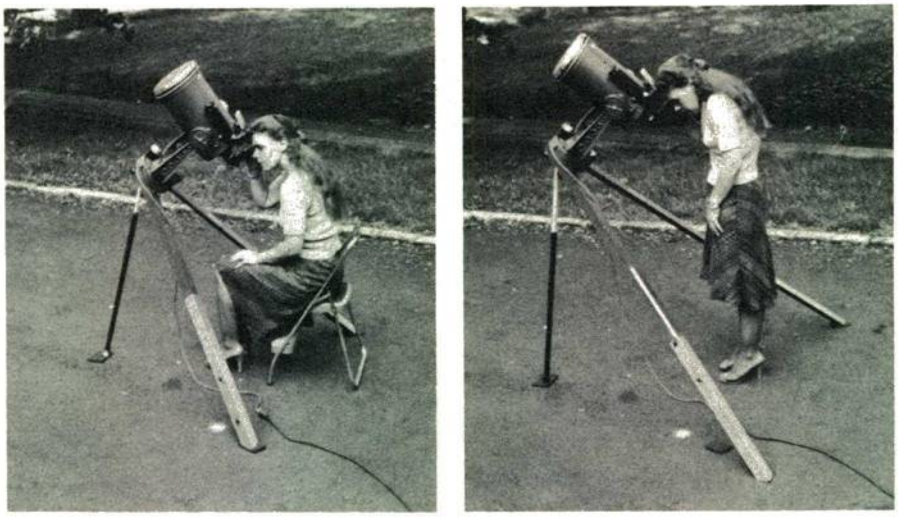

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# ASTRONOMY REVIEWS

**Agfapan 400 Professional Film**
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When I first learned that Agfa was introducing a 400 ASA black-and-white film to the U.S. market, I expected that it — like Ilford HP4 and HP5 — would be virtually indistinguishable from Tri-X. But this is not the case. Agfapan 400 Professional represents a genuine alternative and deserves serious consideration from those of us who use Kodak and Ilford products.

Agfapan 400 is noticeably finer-grained. This is its biggest advantage because it is ideal for situations in which Tri-X is too grainy and Plus-X too slow. But the finer grain has a drawback: considerable loss in "pushability." When the Agfa people say 400 ASA, they mean it, and you'll get little effective speed increase by overdevelopment. Thus for most of our purposes, Agfapan 400 Professional is intermediate between Plus-X and Tri-X in speed as well as granularity.

Development times for Agfapan 400 are about 25% longer than those for Tri-X and HP5 in the same developers — but beware of severe overdevelopment which can greatly increase grain. I'd suggest using a high-energy developer such as Acufine or Microphen, since in astronomical applications you need all the speed you can get. (D-19 might work well when extra contrast is desired.) Naturally, Agfa recommends their own Rodinal, which will give maximum sharpness but less than maximum speed.

Agfapan 400 also requires slightly more time in the fixer than do Kodak and Ilford films; this may have something to do with the Agfa emulsion's two-layer structure.

Agfapan 400 is ideal for lunar and planetary photography at relatively high f/ratios (f/50 and slower); the finer grain makes a noticeable contribution to picture quality as compared with HP5 or Tri-X.

It's also worth trying on star-field photographs. The fine grain results in a pleasing look of overall smoothness, and under certain circumstances, heavily overexposed bright stars are encircled by very attractive halation rings. *Michael Covington*

**Earthlike Planets**
Bruce Murray, Michael C. Malin, and Ronald Greeley
387 pages, hardcover $24.95, paperback $14.95
W.H. Freeman (1981)

In the early 1960s, geologists invaded what had until then been the realm of astronomers when Eugene Shoemaker and others in his field applied the standard techniques of terrestrial mapping to the Moon. What emerged was a preliminary geological history of the Moon and a new hybrid science: planetary geology.

Since then, Mariner, Viking, Voyager, Pioneer, and Venera probes — together with manned and unmanned lunar missions — have visited all of the earthlike planets. What we have learned from these visits is the subject of *Earthlike Planets*.

The book opens with what we knew and thought we knew about Earth's nearest neighbors and adds the information gleaned from probes as it progresses. Early in the history of this science, with little solid data on which to build theories, scientists supposed that the Earth and other inner planets formed slowly and were cold inside after accretion. They thought that a slow outgassing of volcanic gases created secondary atmospheres for Earth, Venus, and Mars and speculated that the cratered highlands of the Moon recorded the last stages of its accretion. And most scientists — though not all — thought the mare plains were lava plains that formed much later. Chapter 1 reviews these theories and takes a look at where we went wrong.

In a chapter entitled "The Global View," the authors survey the overall properties and environments of the Moon, Mercury, Mars, and Venus. Together with our own Earth, these five are very individual worlds — but clearly sibling-planets.

"Modification from Within" covers the processes of impact cratering, wind and water erosion, and gravity-driven mass movements that sculpt and tear down the surfaces of planets. Cratering has battered everything; landslides and slumping are universal, too. Wind and water have modified both Mars and Earth, though in different proportions. Venus is still too poorly known for anything but speculative descriptions.

"Renewal from Within" reviews the agents that rebuild landscapes battered and torn down by cratering and erosion. Volcanism was endemic in the early solar system, and all Moon rocks — even the crushed and rewelded breccias from the lunar highlands — were originally molten. Vast lava plains and towering shield volcanos testify to martian volcanism. Moon-like plains, probably volcanic, cover parts of Mercury. Venus, crudely mapped by radar, seems to have been more active. And Earth, with its plate tectonics and shifting continents, will likely remain active for billions of years.

Chapters 5, 6, and 7 are the heart of the book. They present close-ups of the features and geological histories of the Moon, Mercury, and Mars.

Each planet's past shares similarities: hot accretion, perhaps with global magma oceans, followed by early outgassing and core formation. Then — for a half billion years — the leftover debris of planetary birth bombarded these planets and made its contribution to their developing landscapes.

The smallest bodies soon aged and became geologically dead. On Mars, activity has continued, though at diminished rates. Earth and Venus, the largest of the group, have held and generated the most heat, and Earth, at least, is still very active. Chapter 8, "Comparative Planetology," compares and contrasts these bodies and draws the common threads together.

As the book was being written, the web of knowledge about our solar system was expanding outward. Six of the book's color plates, and several black and white photo mosaics, show Jupiter's four Galilean satellites — courtesy of Voyager 1's explorations.

Io, the innermost, is the last terrestrial planet to be explored. Heated by a gravitational tug-of-war, Io lost its water and now spews volcanic geysers of sulfur and $SO_2$ into the surrounding vacuum. The other moons are icy — a new kind of body, cousins, rather than brothers or sisters, of Earth. Only the asteroids, multitudes of earthlike planets in miniature, are yet to be mapped.

But the exploration is not over. Polar orbiters could map the chemistry, minerology, and geophysics of the Moon, Mercury, and Mars. Most of our knowledge of venusian geology comes from Pioneer's fuzzy altimetry and earth-based radar roughness maps. Global altimetry does not yet cover the Moon, Mercury, or Mars. The list of the "as-yet-undone" fills volumes of technical reports.

As a qualitative text, *Earthlike Planets* succeeds, though some ASTRONOMY readers may find it slow going in places. For example, too much is written about anonymous researchers: The people who actually did the work summarized here are largely missing from the book. I suppose this is inevitable in a text, but I think it is carried too far here.

*Earthlike Planets* also features a unique appendix: a "Guide to Planetary Photography." Every photo in the book is listed with its identification number and source. If you see one you like, you can order a copy. And each chapter has a select reading list for further exploration. *Edwin Strickland.*

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One of astronomical photography's great challenges is getting the image sharply focused. Microprism finders, good for ordinary photography, don't work with lenses slower than about f/5, and even a plain groundglass gets hard to use beyond about f/10.

Moreover, in astronomical photography you focus and take the picture at the same aperture — there's no automatic stop-down to increase the depth of focus. Your margin of error is very slim, too. For example, to get an f/10 telescope to resolve more than 50 lines per millimeter, you have to get the film within a third of a millimeter of the focal plane.

The most accurate way to focus a slow optical system is to use a focusing screen that has a central clear spot with cross hairs or a grid marked on it. Focus your eye on the cross hairs and adjust the telescope to bring the object you're photographing into focus. If the image is big, dim, and blurry — such as the Moon or a planet at f/100 or slower — this will suffice.

But in the awkward range between f/10 and f/100 (common for lunar and planetary photography) cross hairs on a clear spot won't do the job alone —

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you'll need magnification as well. This makes the image bigger and, more importantly, will limit the extent to which the shifting focus of your eye can throw things off. The only hitch is that magnifying finders are expensive — about $100 if your camera is an Olympus, $200 if it's a Nikon or Canon.

Spiratone, the country's largest mail-order camera accessory dealer, sells a magnifying attachment that costs about $15 and fits practically any major-brand 35mm SLR. (You must specify what kind of camera when ordering.) The Spiratone Critical Focuser is essentially a 2x Galilean telescope through which you peer into the camera's eyepiece. It attaches to the camera with a hinged bracket so you can flip it out of the way whenever you wish to see the whole field of view unmagnified.

Its 2x magnification is helpful even if you don't have a cross hair-type focusing screen. In fact, a groundglass screen actually works better for focusing star images, because with the black of space filling most of the field of view, you won't see the cross hairs easily. If your camera doesn't allow you to interchange focusing screens, use the groundglass area that typically surrounds the central microprism or split-image spot.

All right, $15 won't buy you optical perfection. The view through Spiratone's focuser is a good deal less crisp than that through the Olympus Varimagni Finder, say, but so what? The Spiratone model does its job adequately.

A second disadvantage is that the focuser provides virtually no eye relief. And even when you get your eye right up to the eyepiece, you always see a vignetted field. Those who wear glasses will find this bothersome, especially if they focus on something other than the dead center of the screen — because the center has microprisms, perhaps. In this case, take off your glasses and readjust the magnifier to get a sharp, corrected view.

But all in all, the Spiratone Critical Focuser is a real bargain and a very useful accessory. After several months of using one, I find myself wondering how I ever got along without it. *Michael Covington.*

**Voyage to Jupiter**
David Morrison and Jane Samz
199 pages, paperback, $7.50
NASA (1980)
[order as NASA SP-439 from U.S. Government Printing Office, Washington, DC 20504]

Though its title hints at science fiction, *Voyage to Jupiter* is all fact, based on the data and photos of Voyager 1 and 2. At times a bit technical, the book is interesting nevertheless, and brings readers up to date on the latest findings of these fabulously successful missions.

The authors first introduce the jovian system and explain what observers knew about it before probes explored it. Then, in succeeding chapters, they discuss the mid-70s Pioneer spacecraft and their findings and the birth of the Voyager project.

Unfortunately, "Science and Scientists," the chapter on Voyager's scientific payload, does little to help laymen understand the complex instruments aboard. Its technical and complicated ideas and theories are explained in a complicated manner. But it's the only real clunker in the book, and many difficult ideas are simplified later when the data from the spacecraft are more thoroughly explained.

Several chapters deal with the actual launch and operation of the two spacecraft, the problems they encountered *en route* to Jupiter, and the many scientific surprises transmitted to Earth during the encounters. The two chapters on the flybys give a day-to-day account of mission highlights, and their text conveys the excitement of exploration, while extraordinary photos draw the reader in.

The last chapters of *Voyage to Jupiter* sum up our understanding of Jupiter and its family of moons. This is the core of the book. The authors unfold Jupiter's past history — from new and previously-known data — and explain the planet's atmosphere, weather patterns, ring system, magnetosphere, and magnetic field structure as we understand them today.

*Voyage* concludes with a fascinating chapter on our new views of the Galilean satellites and a section explaining the proposed Galileo spacecraft that is scheduled to explore Jupiter in even greater detail later this decade. Although it has certain rough spots, this book is an excellent recap of what the Voyager missions accomplished — and how and what we learned about the giant planet. *Dan Koehler.*

**Pulsars**
W. Sieber and R. Wielebinski, eds.
475 pages, paperback, $28.95
D. Reidel Publishing (1981)

Subtitled "13 years of research on neutron stars," this book contains the papers given at an IAU symposium in August 1980. The level of presentation is highly technical.

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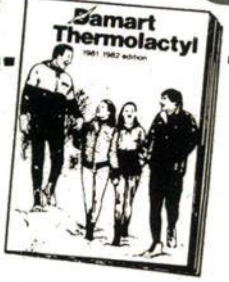

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# The Infrared Universe, Part II

by Clarence H. Annett

If we could see infrared radiation, what would the universe look like? The answer depends on what portion of the infrared spectrum we are talking about. A person on the Earth viewing the world at a wavelength of about 10 micrometers would be treated to a spectacular "light show" where everything emitted infrared radiation. The intensity would be greater with warm objects, but even the inside of a deep freeze would glow. Astronomically, the picture would be disappointing. At short-infrared wavelengths the sky would be so bright from its own radiation that night would not exist, and we would see nothing but the Sun. At longer wavelengths, extending out into the far-infrared, the sky would appear dark and starless, because of strong atmospheric absorption. In fact, a person with "infrared eyes" would spend his life in a perpetual pea-soup fog.

But imagine for a moment that we could get above the atmosphere: there the universe would be as spectacular as the visible-light universe — but very different. It is a peculiar fact of infrared astronomy that what can be seen depends on what wavelength you observe. Short wavelengths reveal "point" objects such as stars. In the photographic infrared, for example, we would see a starry sky but no familiar constellations, because the relative magnitudes and colors of the stars would be changed. Cool stars like Betelgeuse and Arcturus would stand out, while hotter stars like Vega, which emit most of their light in the visible spectrum, would be very faint or invisible. Extended objects such as nebulae would be conspicuously absent from this short-wave infrared sky. In the mid and far-infrared, however, the stars would become less prominent and we would see more extended sources, particularly nebulae and additional objects like regions of stellar formation. If we could look at all infrared wavelengths simultaneously, we would see every type of object seen in visible-light and more.

Infrared astronomy enjoys a particular advantage over visible-light astronomy: there are no "hidden corners" in the infrared universe. Telescopes that observe the visible spectrum cannot detect some celestial objects for either or both of two reasons. The first is that the object may be too cool to emit visible light. If this is the case, it can be detected by infrared telescopes. Many such cool objects are now known. The coolest, youngest and most energy-emitting stars in the universe belong to this group. If present theories are correct, these cool infrared objects may be various stages of stellar birth.

The second reason for observing celestial objects in the infrared is that the universe is quite dusty. Vast dust clouds lying between our solar system and many deep-space objects obscure our view. The dust particles absorb and scatter visible light rays, but interact very little with the longer wavelength infrared. Infrared astronomers thus have the capability to "look through" dust clouds and see what lies hidden behind them.

Another advantage of infrared is that it is the domain of molecular transitions and their associated radiation just as visible light is the domain of atomic transitions. Infrared reveals the glow of molecules between the stars, while visible light reveals the glow of interstellar atoms.

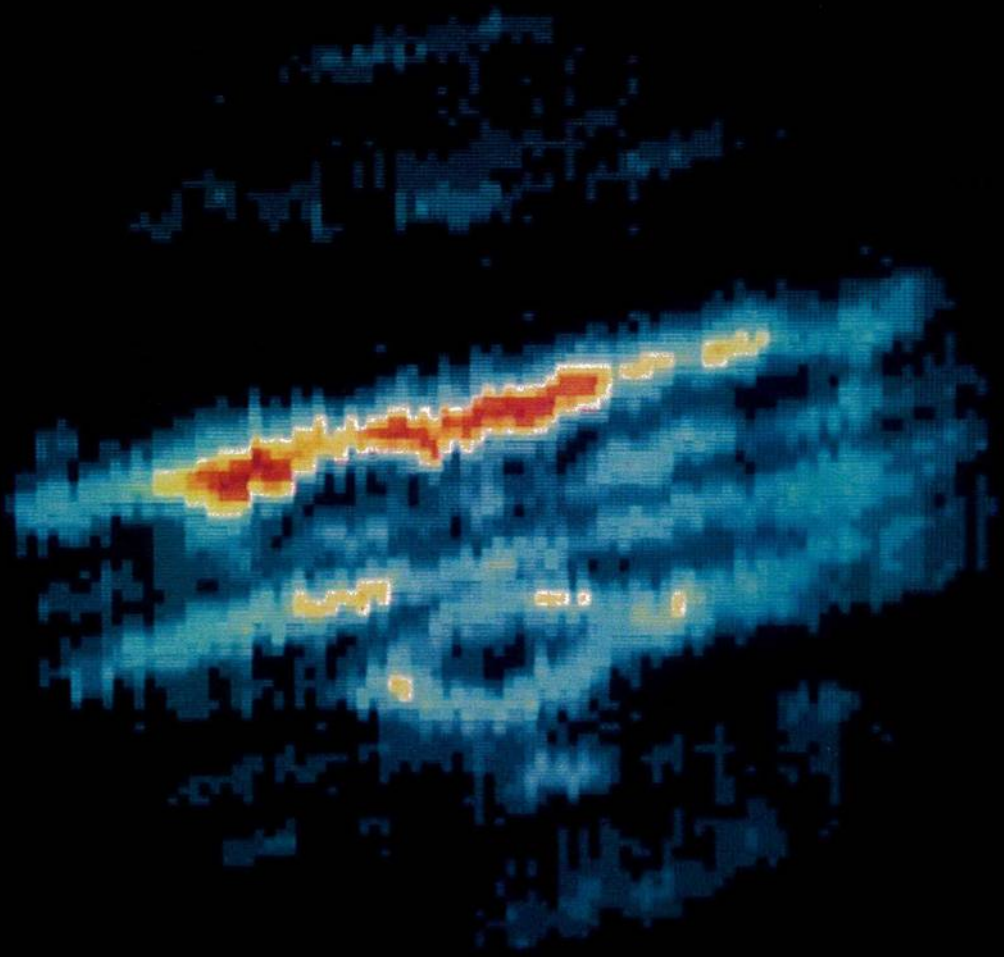
When electrons jump between the orbits of single atoms, the resulting photons produce a spectrum with sharp, narrow lines in the visible part of the spectrum. The temperature of the gas and the atoms in it can be inferred from the spectrum. But transitions of electrons in molecules are more complex. Their radiations are broad bands rather than sharp lines. The infrared spectrum yields information about the molecules. Since the radiation from a variety of molecules has been studied by chemists, infrared astronomers can use this data to identify molecules in distant parts of the universe. Unfortunately, the wavelengths of some of the most interesting molecular transitions coincide with wavelengths where atmospheric absorption is the greatest.

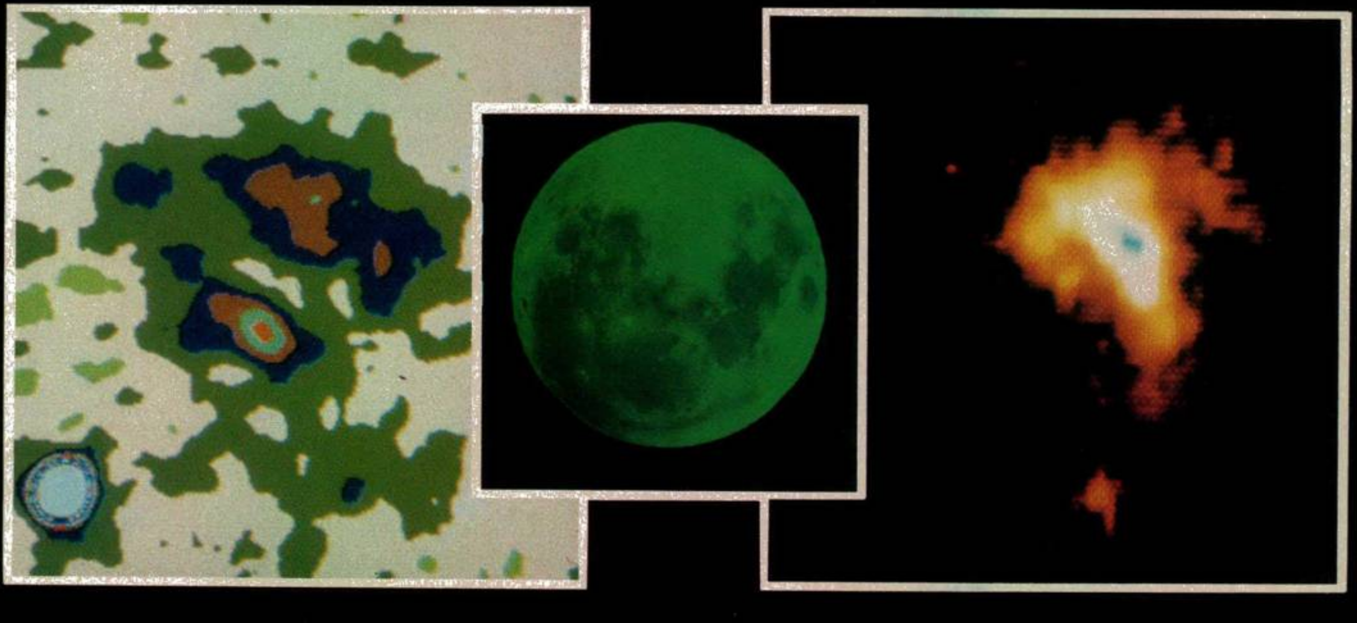
Nearly all celestial objects radiate in the infrared — each in a different way — and infrared astronomy rounds out our knowledge of these sources. Through it we are allowed our only glimpse of many objects. Infrared's dust-penetrating ability lets us see into many areas of the universe that are veiled to the optical astronomer. By choosing the correct wavelengths, we can use infrared to peer into different layers of planetary atmospheres, thus discovering their temperature and composition. The use of infrared as a research tool will give us more data than we had before on any object in the universe.

The Sun is a huge ball of super-hot gas held together by its own gravity, but kept from collapsing by the pressure of radiation from nuclear fusion reactions deep within its core. Because the Sun consists of several regions of differing temperatures, infrared radiation is useful as a probe of these regions and their boundaries. At very short wavelengths — less than two micrometers — we can see slightly below the solar surface. Short-wavelength infrared radiation arises in the photosphere, or visible surface of the Sun. Mid-infrared radiation comes from the chromosphere, or lower atmosphere. The region of transition between the photosphere and chromosphere has its own peculiar infrared signature between 50 and 150 micrometers. Some far-infrared radiation has been identified with processes occurring in the corona, the Sun's outer atmosphere. By choosing the proper wavelength, the infrared astronomer can control how deeply he looks into the Sun.

Solar infrared radiation is rich in molecular transition

**A detector sensitive to 5 micron infrared radiation obtained this view of Jupiter through the University of Hawaii's 88-inch telescope. Bottom (left to right) are 10 micron images of the Galactic Center, the Moon photographed on commercial infrared film, and the BNKL infrared source in M-42 photographed at three different wavelengths. Photos courtesy Hawaii Institute of Geophysics, George F. Hodgkinson and the University of Wyoming.**



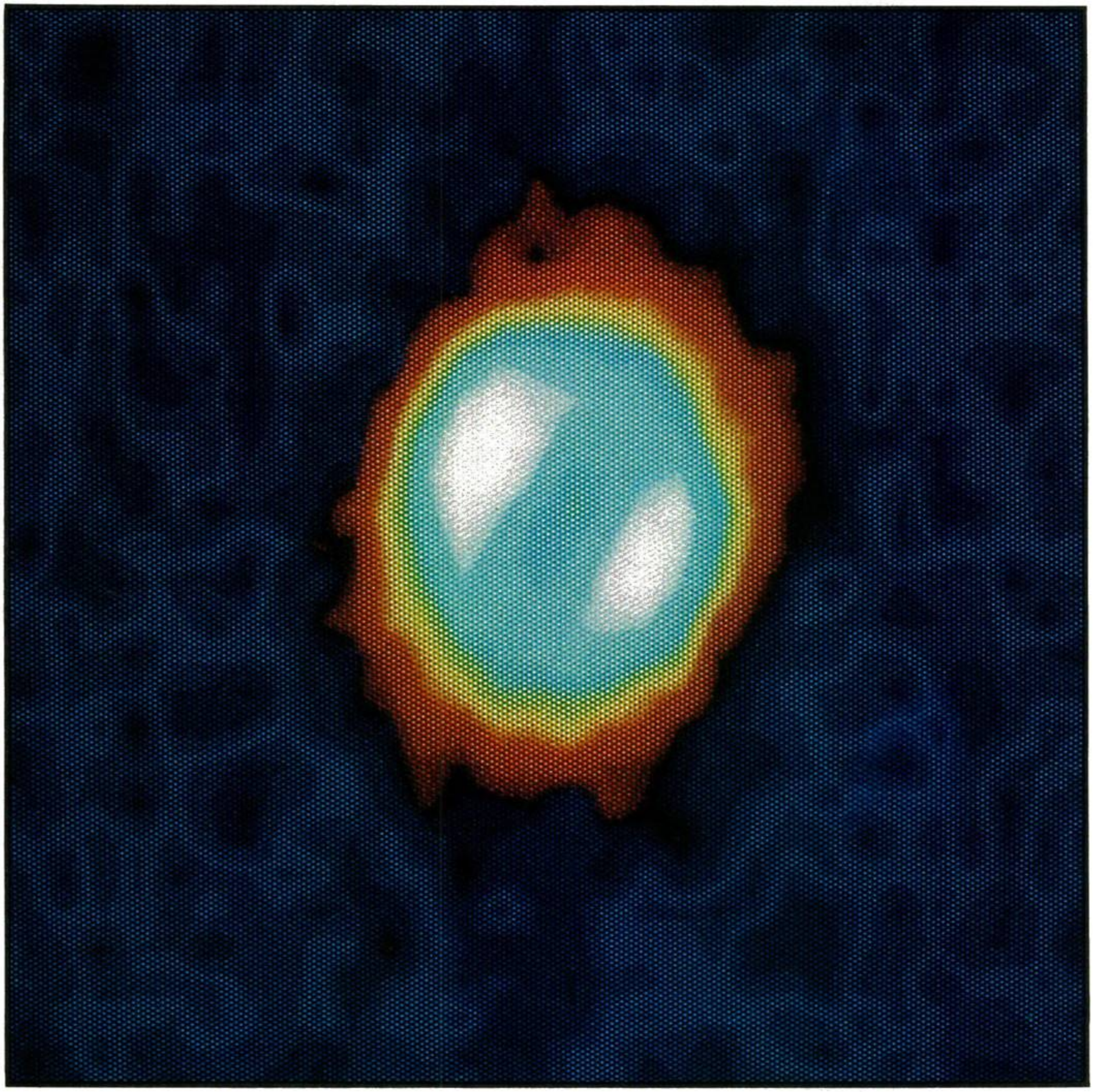


spectral lines. These lines represent a tremendous source of data on molecular populations and reactions in sun-like stars, but observing them is difficult due to Earth's atmospheric absorption. Because of this, far-infrared solar observations have been used mainly to measure the Sun's temperature at various levels above its surface and compare the results to the predicted temperatures. The agreement has been very good. Of course, infrared solar observations are also useful in interpreting infrared observations of other stars too distant to be observed in detail.

William Herschel first detected infrared radiation in sunlight, but the next significant result in infrared astronomy concerned the Moon. The Full Moon was first detected with a thermocouple in 1856, and by 1870 it had been observed in the infrared through all its phases. It took nearly a century for improved detectors and advances in radiation theory to yield the next result. A measurement during a total lunar eclipse in the 1940s showed that the lunar surface cooled more than expected during the short duration of totality. Scientists then lacked today's electronic computers and, therefore, spent several weeks making the calculations needed to explain this result. These calculations showed that the lunar surface was not solid rock, but was covered with a layer of dust. Although it was published in 1948, this hypothesis was not confirmed until the 1960s when the Surveyor spacecraft sent back pictures of the surface and the Apollo astronauts ventured out and left their footprints in the dust.

During two total lunar eclipses in 1960, infrared observation of the Moon revealed another suprise — some small areas remained much hotter than their surroundings when the Earth cut off the flow of sunlight heating the

**An 8.7 micron image of the planetary nebula NGC-7027 in Cygnus located very close to Deneb. All slides from the University of Wyoming are computer reconstructions of infrared data obtained with the 92-inch telescope of the Wyoming Infrared Observatory, and have been processed using the new WIRO image processing system. Slides courtesy R. Gehrz, G. Grasdalen, J. Hackwell, A. Herzog and A. Bentley of the University of Wyoming.**



surface. Theoretical work identified these "hot spots" as exposed rock outcroppings. This was verified by high-resolution photographs from the Lunar Orbiter and various Apollo missions.

All the planets, most of their satellites, and many asteroids have been observed in the infrared and each presents a unique infrared "signature." Mercury behaves as a nearly perfect blackbody radiator; it has a dust layer much like the Moon, and is very hot. Its surface temperature has been measured by balloon and ground-based telescopes and was confirmed by an infrared radiometer aboard the Pioneer spacecraft as being approximately 600°K in some spots.

Venus and Mars both have atmospheres and appear very different in the infrared. Venus' atmosphere is so thick that we see only the top layer even in the infrared. Mars has a much thinner atmosphere, so we see a mixture of infrared radiation from its atmosphere and surface. Both planets are too small for ground-based or balloon-mounted infrared telescopes to map surface detail, but infrared photometers carried aboard the Mariner and Viking spacecraft carried out this task.

Uranus, Neptune and Pluto are so distant and faint that they present difficult targets for infrared telescopes. Surface temperature measurements are subject to large error, and attempts to detect molecules in their atmospheres have been of limited success. Recently the Doppler shift of the infrared absorption bands of methane was measured for Neptune and Uranus; this allowed a new rotation rate for these planets to be calculated.

Asteroids are strong infrared emitters and are easily observed from Earth. By comparing the infrared and visible light reflected and emitted by the asteroids, astronomers can deduce asteroid diameters. Furthermore, the infrared bands indicate that some asteroids have a reflection spectrum resembling meteoritic material. Long-term observations of "light curves" show that some asteroids are very irregular and highly elongated in shape. Since no space probe has visited an asteroid, infrared data have played a major role in extending our ideas of their nature.

Jupiter and Saturn are also strong sources of infrared radiation and exhibit peculiar behavior. Both planets radiate nearly twice as much heat into space as they receive from the Sun. This excess heat represents the release of gravitational energy.

When comets approach perihelion, infrared astronomers work feverishly to determine their temperature, structure, and composition before these impressive visitors recede into the cold blackness of space. However, only a few comets have been measured in the infrared. The most famous and well-studied is Comet Kohoutek (1973f). At 20 micrometers, it had a magnitude greater than -6 — the brightest comet measured in the infrared. Much of our knowledge of comet structure comes from infrared astronomy. The advances in detector technology that have taken place since 1910 make Comet Halley's return encounter an event eagerly anticipated by infrared astronomers.

Nearly all the planets' satellites have been observed in the infrared. Some have atmospheres and some do not. For those that do, the infrared astronomer tries to deduce the chemical composition of the atmosphere. For those with no atmosphere, astronomers try to measure the surface temperature and then infer the nature of the surface from the infrared spectrum. Although ground-based observations have lost some of their importance since space probes such as Pioneer, Voyager, and Viking have passed close to many of the satellites and returned pictures of the surface and data from on-board infrared radiometers, they are still important for long-term studies.

Stars, too, are studied in the infrared. To the infrared astronomer, cool stars — especially those visible only in the infrared — are far more interesting than hot stars. Stars are probably born as local density variations, *knots*, in a cloud of dust and gas. These knots grow by gravitationally attracting more gas and dust until there is enough mass and internal pressure for nuclear fusion to begin. Dust clouds surround these newborn stars and hide them from our eyes until they reach an advanced stage near the main sequence called the *T Tauri* stage. They then develop strong stellar winds and blow away the remaining dust, allowing their light to reach us unobstructed. Although the dust cloud initially hides a young star, the infrared radiation from the star passes through it augmented by infrared radiation from the warm dust itself. With infrared astronomy we get our first glimpse of star birth.

Nebulae like the Great Nebula in Orion (M-42) are clouds illuminated by the stars within them. Many similar areas are known as HII regions because they are mainly composed of singly-ionized hydrogen atoms with a special infrared signature. Herbig-Haro objects are reflection nebulae that are illuminated by nearby young stars not in the clouds themselves. They are not infrared emitters, but simply reflectors of the infrared radiation from nearby T Tauri stars.

Most hot stars are invisible or very faint in the infrared, so they hold little intrinsic interest for the infrared astronomer. A few oddballs, however, show an excess of infrared radiation: O, B, A, or Wolf-Rayet stars enveloped in dust, and those with planetary nebulae.

The early stars surrounded by clouds of gas and dust shine by exciting the gas to glow in the infrared. The clouds contain large amounts of hydrogen which is ionized if the star is hot enough. If the star is very hot, the spectrum shows emission lines that are absent from ordinary stellar spectra. Features called *forbidden lines*, not observed in terrestrial laboratories, occur because even in the clouds of dust and gas, the vacuum of space is much greater than any vacuum produced in a laboratory. In this greater vacuum, electrons are free to jump between atomic energy levels by following pathways they cannot follow when the vacuum is not as great. The Eta Carinae Nebula, for example, has an infrared spectrum dominated by forbidden lines and is also the brightest infrared source (at 10 and 20 micrometers) in the entire sky.

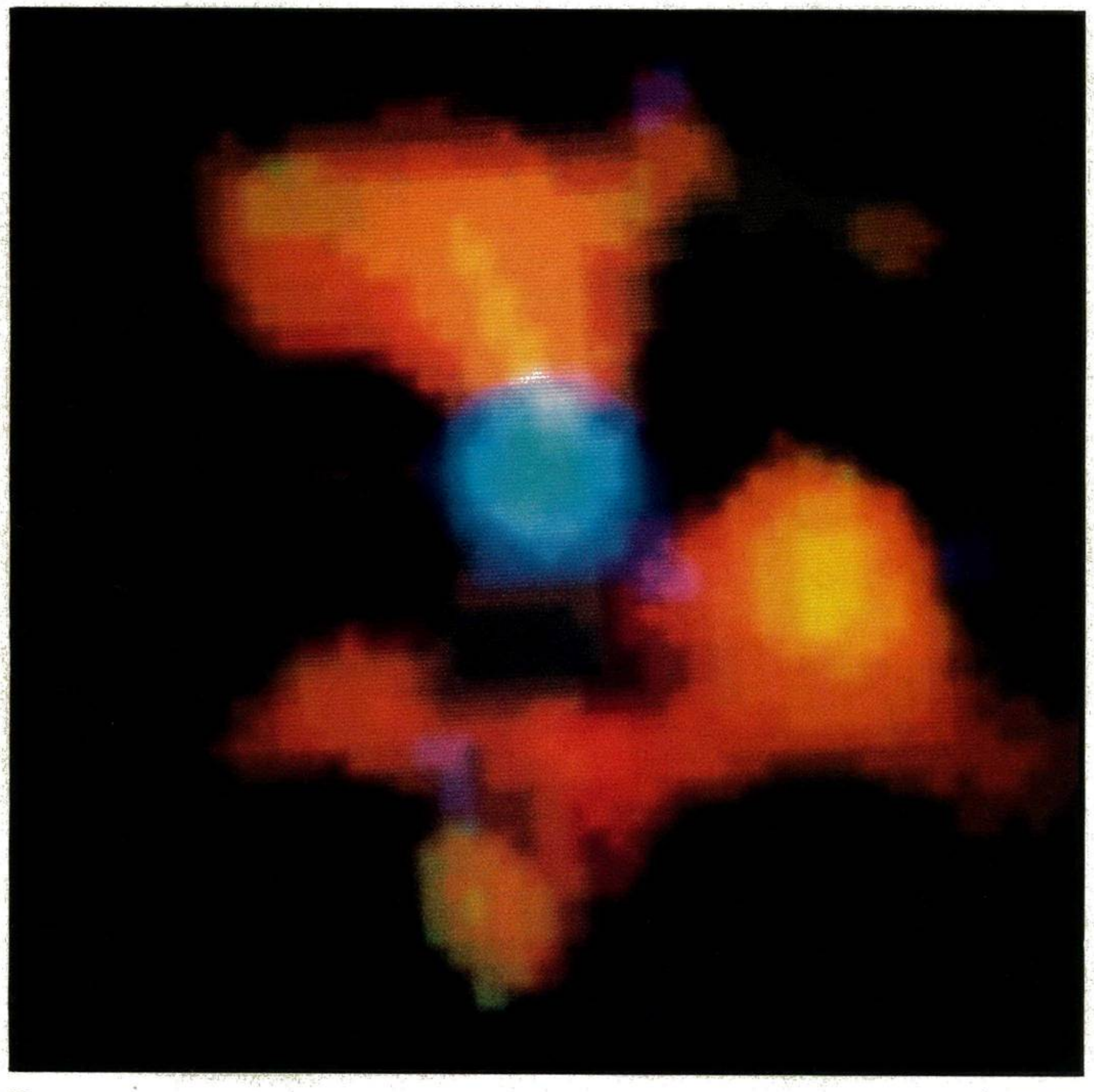
When stars age, some throw off shells of gas that form planetary nebulae (see "Mass Loss from Stars," November 1979). These nebulae are cooler than the clouds around early-type stars and astronomers must observe them at different infrared wavelengths. About half of the known planetary nebulae don't conform and show an excess infrared radiation over that expected. Perhaps the excess comes from dust mixed with the nebula. If this is so, then two questions about planetary nebulae remain unanswered: how much dust (in proportion to gas) do they contain, and how is the observed infrared excess related to the type of central star? Astronomers speculate that planetary nebulae evolve from cool, late-type stars. If this is true, then some of the gas the star sheds from its atmosphere should condense into dust. This phenomenon is of great interest because gas-into-dust condensation plays an important role in theories of stellar and galactic evolution. Nova and supernova remnants, such as the Crab Nebula, show no infrared excess, so there is indeed something unique about the processes taking place in planetary nebulae.

Many nebulae and interstellar clouds are not easily observed from Earth because they are only bright in the far-infrared. This is especially true for HII regions, but fortunately these areas are also strong radio sources, so there is no great gap. The far-infrared maps the distribution of dust, while the radio maps the distribution of ionized gas. In most cases the maps are similar, but there are a few surprises. A large discrepancy in the infrared and radio maps of the Orion Nebula led to the startling conclusion that the nebula is much denser than expected — so dense, in fact, that it is not ionized all the way through.

In addition to the HII and dust clouds, our Milky Way Galaxy contains many clouds rich in molecules. They too are studied by radio and infrared techniques. A score of molecules have been identified in them, including $H_2$, CO, CH, OH, CN, $CO_2$, and $H_2O$. The heat needed to set off these chemical reactions comes from nearby young stars.

The theory of star formation is neither satisfactory nor complete, and much remains to be determined about how young stars form out of the clouds of gas and dust, and how they evolve toward the main sequence. Since the details of star birth and infancy are veiled in dust clouds, infrared astronomy is the only method available for observing this first step of stellar evolution.

The nuclei of galaxies are interesting to study because we can see processes taking place in them that happen nowhere else. We can see this in other galaxies' nuclei, but their great distance from us makes careful study difficult. The Milky Way's nucleus is obscured from view by dust and gas, but its proximity makes study easier — especially with the penetrating ability of infrared (see "Journey to the Center of the Galaxy," August 1980). We know now that the nucleus contains not only the older Population II stars, but many young Population I stars and a number of supergiants that were not expected at all. In addition, high-resolution radio, infrared, and combined radio-infrared maps of the nucleus indicate that the galactic core contains several separate, very bright emission sources clearly too large to be stars. The brightest of these regions, Sagittarius A and B, are not fully understood, but possible explanations of how so much energy can be produced in such a small volume include massive black holes, molecular clouds, and extremely compact associations of very hot stars. Sagittarius



**A three-color composite image of the HII region S-106 in Cygnus taken at 3.6, 10, and 20 microns. The hottest area is the source near the center with a color temperature of 920°K. The 92-inch telescope at the University of Wyoming was used for this composite. Photo courtesy of R. Gehrz, G. Grasdalen, J. Hackwell, A. Herzog and A. Bentley.**

A is now regarded as the center of our Galaxy.

But there are advantages and disadvantages to all astronomical tools. Just as cosmic dust distorts and obscures what an optical astronomer sees, the process of *reddening* works against the infrared astronomer. Radiation that passes through dust clouds is reddened — its shorter wavelengths are scattered and diminished more than its longer wavelengths. This is much like the process that makes sunrises and sunsets red. A correction must be applied to the reddened spectrum to recover the true spectrum. For nearby objects, correcting this effect is easy, but as the objects become more distant, the combination of the uncertainty in true distance and in the amount of intervening dust often makes the correction little better than a guess. Sometimes this problem can be solved if the object is also a radio emitter, because better distance measurements can be made by a radio technique called very-long baseline interferometry (VLBI) (see "Using Earth as a Radio Telescope," October 1979). If the nature of an object is known and the distance to it is established very precisely, the amount of reddening can be used as a probe of the dust cloud.

Reddening is a particularly insidious problem to astronomers searching for objects on photographic plates. Since most emulsions are more sensitive to blue light, a highly-reddened object will not show up on them. Infrared astronomers have discovered several objects that do not show up on the famous Palomar Sky Survey plates. Some infrared objects are dimmed as much as 30 magnitudes by reddening.

But in 1969, the Italian astronomer Paolo Maffei turned the disadvantage of reddening into an advantage and made a major discovery. He noted two faint nebulous objects on a photographic infrared plate of the Milky Way in Cassiopeia. He realized these objects were invisible on ordinary photographic plates. Thorough study showed the objects, later named Maffei 1 and 2, to be extremely luminous and massive galaxies in the Local Group. Their spectra are so highly reddened that they cannot be observed except in the infrared. Systematic infrared studies of the sky beyond the plane of our Galaxy, the *zone of avoidance*, have revealed that it is not devoid of galaxies as previously believed. Instead, it contains quite a number of bright galaxies whose spectra are highly reddened, like the Maffei objects.

Not all galactic nuclei are as calm as ours. The "exploding" Seyfert galaxies have nuclei that are bright in the optical spectrum and show a tremendous excess of infrared emission indicative of violent internal processes. The Seyferts also have spectra rich in emission lines. Other infrared objects of interest include: galaxies such as NGC-4151, which is variable in the infrared; BL Lacertae objects, which emit more infrared than expected; and quasars such as 3C-273 which may be variable and emit more infrared than they should.

Infrared astronomy has made major contributions to our theory of cosmology in two important ways. These are in measuring Hubble's constant and in understanding remnant background radiation.

The measuring stick used to determine distances in the universe is Hubble's constant. It relates the distance of a galaxy to its recession velocity, and was originally determined from measurements in the visible spectrum. Such measurements are subject to large uncertainties because interstellar and intergalactic dust obscures some of the light from the galaxies and alters their spectra. If the amount of dust along the light path is known, the data can be corrected. Because infrared radiation penetrates the dust better, the correction is smaller and the uncertainty in Hubble's constant is reduced. Continuing measurements in the infrared promise better values for Hubble's constant, and, in turn, the size of the universe.

Since there were no observers to record the events at the Big Bang, cosmologists take the evidence available now and use it to reconstruct the beginning and predict the future evolution and fate of the universe. The only remnant of the Big Bang is the thermal background radiation that was discovered at radio wavelengths by Penzias and Wilson in 1965 (see "The Cooling Fire of Creation," March 1980). Radio measurements of the background radiation indicate that the universe has a present temperature of 3° K. However, this is not the whole story. Models of the early universe's evolution depend on the exact value of the present temperature. So it is of great interest to measure other wavelengths — especially the infrared — and reduce the uncertainty in the measured temperature. In addition, measuring the *anisotropy*, or directional unevenness, of the background radiation in the infrared will give valuable information about the birth of the universe that cannot be found otherwise.

Both are very difficult measurements to make, partly because at the wavelengths of greatest interest, measurements with ground-based instruments are impossible. About 20 infrared measurements of background radiation temperature have been reported. They cast some doubt on the actual temperature. In addition, the measured points do not all seem to lie nicely on the same Planck blackbody radiation curve. This may mean that present cosmological models are incorrect and will require substantial modification. In other words — as in many aspects of cosmological study — the final answer is not in yet. An anisotropy in the radio background radiation was only recently measured. No one has yet measured any anisotropy in the infrared background. The expected anisotropy is so small that more accurate measurements are needed to find it. Presently it is extremely difficult to keep a high-altitude balloon aloft and stable enough to make a good anisotropy measurement. For these reasons, anisotropy measurement is a superb candidate for a satellite or space telescope experiment.

Although it is over 100 years old, infrared astronomy is still in its infancy. All-sky maps do not exist for most infrared wavelengths, and the southern hemisphere sky is poorly mapped at all wavelengths. Astronomers must make further improvements in infrared detectors if faint infrared sources are to be discovered and mapped. But there is hope — new solid-state detectors called charge-coupled devices (CCDs) are being tested, and they ultimately promise improvements in sensitivity of ten times or more (see "An Imaging Revolution," November 1980). Existing infrared observations, especially those relating to galaxies, have not been fully explained. More observations may be necessary before all the questions are answered.

A great deal of important data have been collected using rocket, balloon, and airplane-borne infrared telescopes, but infrared astronomy still has a golden age to look forward to — an age of large telescopes in permanent orbit high above the atmosphere. New ground-based telescopes now being designed or constructed will increase the number and quality of infrared observations. And meanwhile, the IRAS satellite telescope and the Space Telescope will supply the first complete sky survey in the infrared. With this will come new challenges for physics and astronomy in explaining the physical mechanisms operating in celestial objects. The most exciting astronomical discoveries of the near future could very well come from infrared astronomy as it continues to peer through the veil of cosmic dust and search out the cool, invisible universe unseen by our own eyes.

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*Clarence Annett recently retired from the University of Kansas Physics Department and has taught at the Kansas State University planetarium and observatory. His current research interest is in laboratory simulation of the martian atmosphere. He is also developing a lab manual in observational astronomy.*

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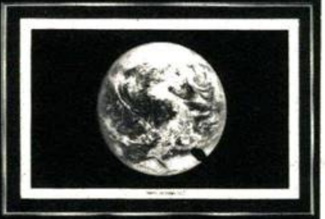

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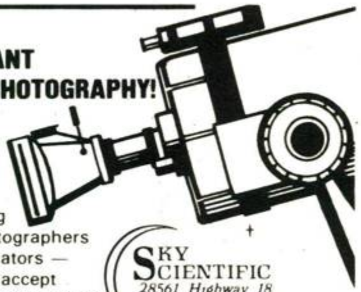

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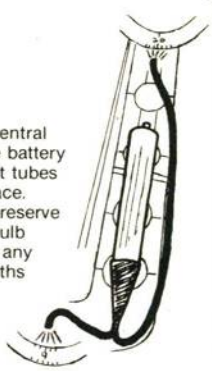

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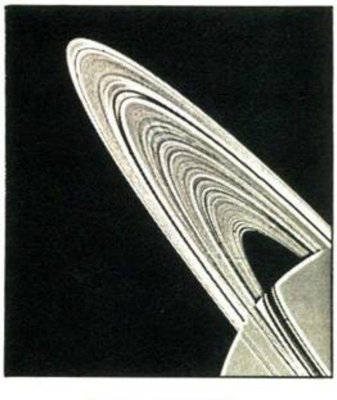

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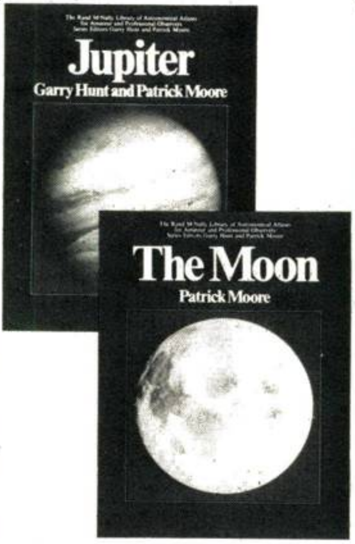

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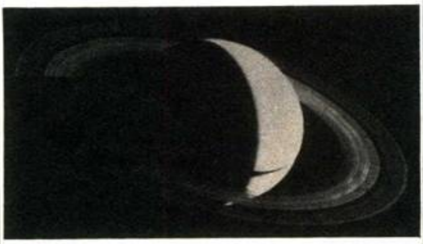

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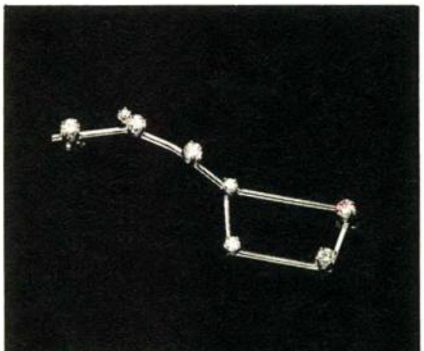

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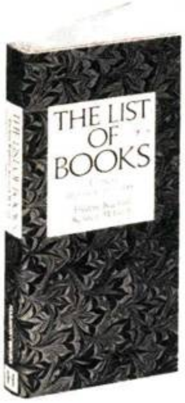

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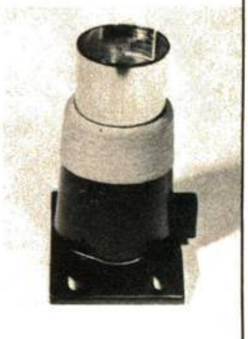

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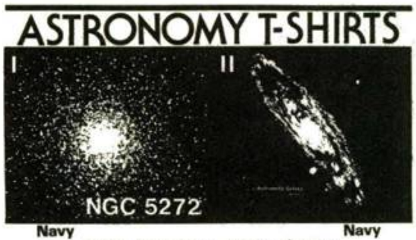

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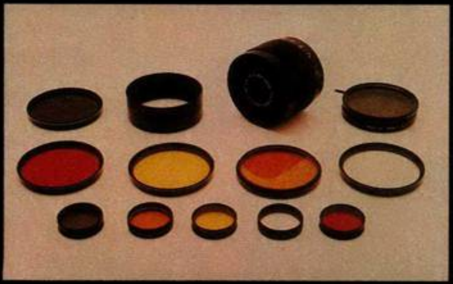
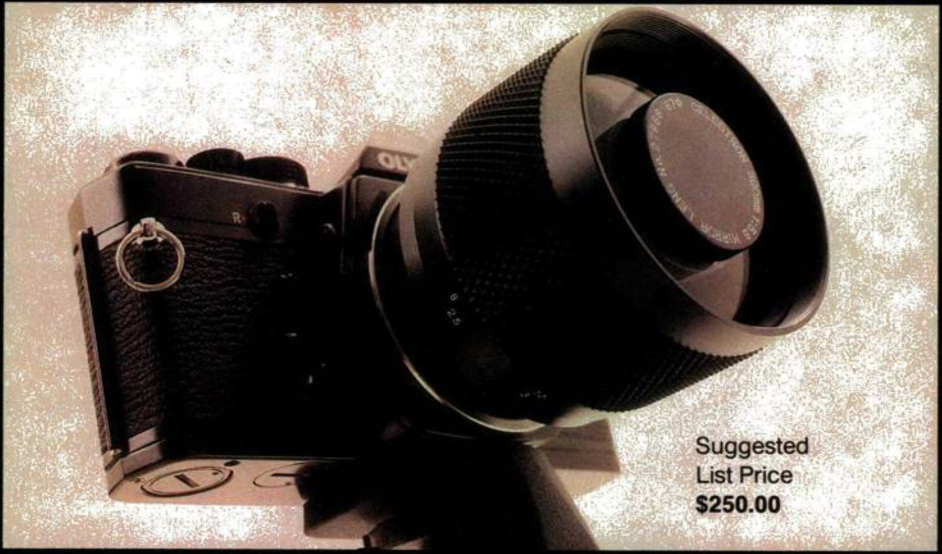


### ACCESSORIES FOR THE 300mm f/5.6 TELEPHOTO

To enhance your use of the Celestron 300mm Telephoto we offer a lens shade and filters.

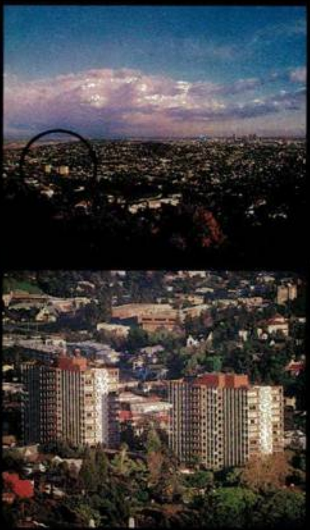
- Lens Shade—300mm. The lens shade will help increase photographic contrast; it will also aid photography when your subject requires you to aim toward the sun.
- 300mm filter set (34mm). This set includes 4 filters: Skylight #1A, Red #25A, Yellow #8, and ND4. These filters thread onto the back of the lens before you attach your camera.
- Full aperture 67mm filters. These filters thread over the front aperture of the 300mm lens. Filters available separately are: Polarizing Filters, Skylight #1A, Red #25A, Blue #80A, Yellow #8, ND2, and ND4.



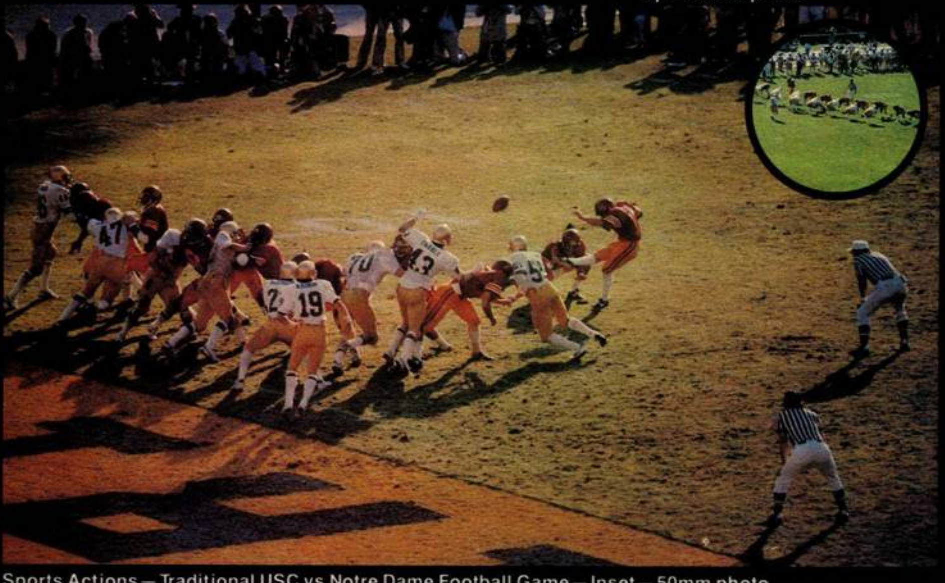
300mm f/5.6 Telephoto Lens Used on a Photo Tripod

Wildlife Photography

Portrait Photography

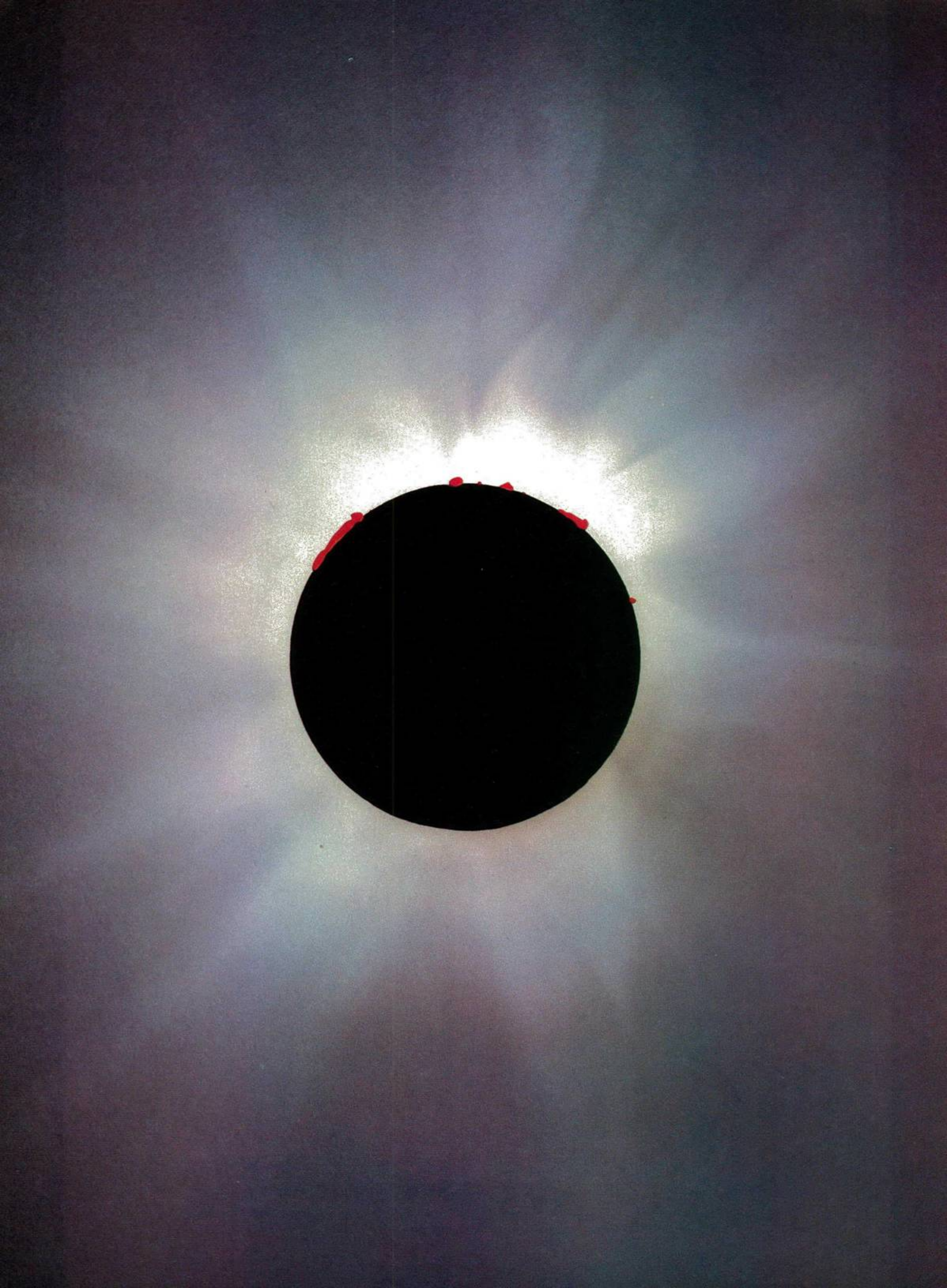


Long Distance Photography— Top — 28mm photo



Sports Actions — Traditional USC vs Notre Dame Football Game — Inset — 50mm photo

SEE BACK COVER FOR CATALOG INFORMATION



# close-up on cepheus

## through the eyepiece

October is a month of transitions; several major planets will pass through conjunction with the Sun, each switching from the evening sky to the morning. As a result, only Venus (in the evening sky) and Mars (in the morning) will be clearly visible during all of October.

### Mercury

From a poor appearance in the evening sky, Mercury will hurry through inferior conjunction (October 18) and rise up rapidly in the eastern morning sky. Unless your view of the eastern horizon is hopelessly cluttered, you should be able to pick up the little planet during the closing week of October.

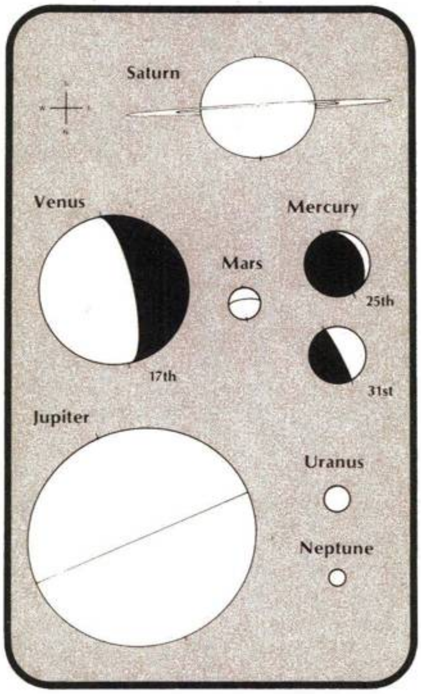
Greatest elongation is on November 3, and Mercury will remain visible in the morning sky for another three weeks after that.

### Venus

During October, Venus remains a prominent albeit low-altitude object in the southwestern sky after sunset. Its phase steadily decreases until the disk is only half-lit, traversing the background stars of Scorpius.

Venus also has several October conjunctions that will be of interest to the telescope owner. On the evening of the 10th, the planet will lie about 30′ of arc away from 2.3 magnitude Delta (δ) Scorpii. (This is the star used by Voyager 2 to measure the density of material in Saturn's rings during the recent flyby.) About 50x will put the star into the same field as the -3.9 magnitude planet. On the 10th, Venus will be 64% lit and at a distance of 0.902 astronomical unit (134 million kilometers).

At around 15h UT on the 14th, Venus will pass about a degree south of the globular cluster M-80 — a 7th magnitude ball of stars about 5′ of arc in diameter. Since this is during daytime for North America, you'll have to look on the evening of the 13th (before the conjunction) or a day later (after it). As with Delta Sco, low to moderate powers will work best to bring the two into the same field of view.



If you look for Venus and M-80 on the 14th, you'll also see a 4.8 magnitude star nearby: Omicron (ο) Scorpii (also cataloged as 19 Sco). Venus' conjunction with it will be at 9:40 UT on the 15th, so be watching on the evening of the 14th.

At 5:25 UT on the 17th, Venus sweeps past Antares, missing it by just less than 2°. Again, the timing is poor for North America — your best view will be on the evening of October 16th. The color contrast between the first magnitude red star and the blazing white planet to the north will be wonderful in any instrument.

### Mars

On the morning of the 19th at around 17h UT, Mars will pass a little over a degree north of Regulus in Leo, but the Sun will have risen over most of North America at the time of conjunction. Mars offers a disk 4.8 seconds of arc in diameter and of +1.7 magnitude. Three mornings later, the crescent Moon will have moved into the vicinity, making a neat triangle with Mars and Regulus.

### Asteroids

At conjunction with the Sun on September 15, 1 Ceres lies too much in the solar glare to be seen this month.

2 Pallas (magnitude 8.9) spends the month of October near the junction of the constellations Leo, Sextans, and Crater. Its positions:

10th: 10h 35m 30s, -4° 59.4′
20th: 10h 54m 36s, -5° 52.9′

This region rises around 6 a.m. local daylight on the 15th.

Both 3 Juno and 4 Vesta will be in conjunction with the Sun next month (Juno on the 23rd and Vesta on the 14th); during October, both lie too close to the Sun to be seen easily.

### Jupiter and Saturn

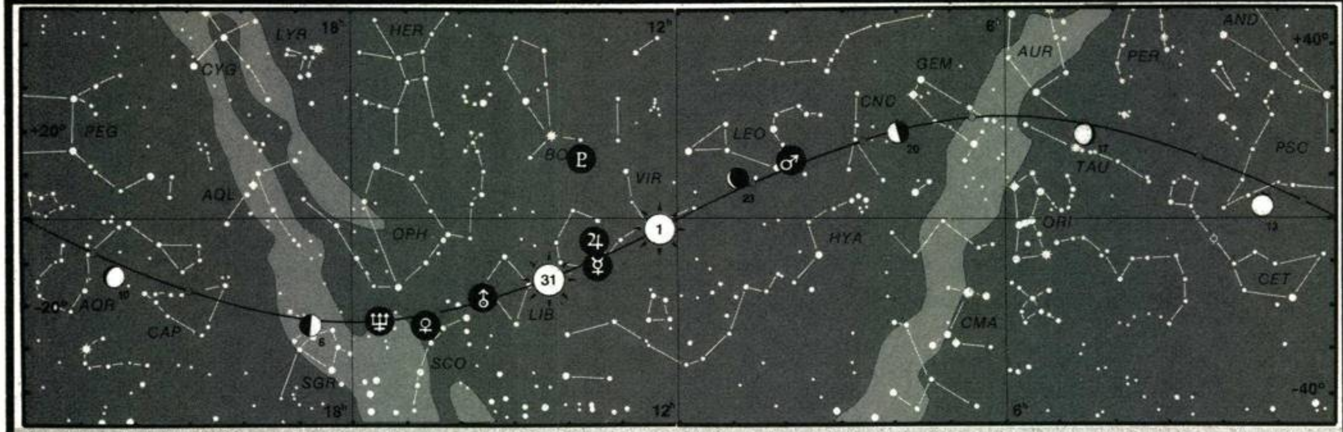
Saturn passes behind the Sun on October 6; Jupiter does the same on the 14th. Both will be too close to the Sun to be seen easily almost all month. Late in the last week of October, though, sharp-eyed observers may catch sight of both as they rise in the east just ahead of the Sun.

### Uranus

Uranus is poised to follow Jupiter and Saturn into the twilight glow of

**Starting with four slides of the February 16, 1980 solar eclipse, Berton Willard used great care, high-contrast copying, and radial-density dodging to make a unique multiply-printed image that shows prominences in their "natural" H[$\alpha$] color as well as streamers in the corona. This is October's "Best Astro-Photo."**

# planetary data october 1981


LYR
18h
HER
12h
6h
AND
+40°
CYG
GEM
AUR
PER
+20°
PEG
CNC
LEO
BOO
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♂
20
17
TAU
PSC
VIR
23
AQL
1
HYA
ORI
13
OPH
♃
☿
31
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CET
-20°
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10
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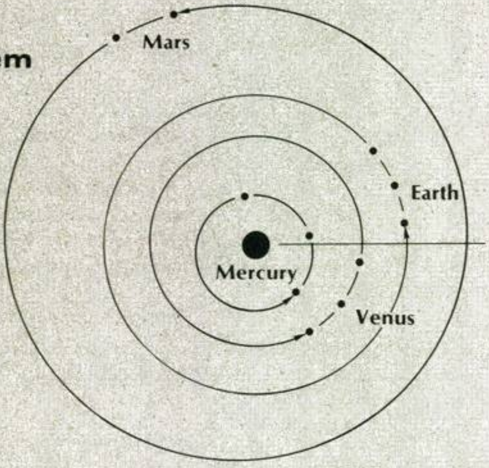
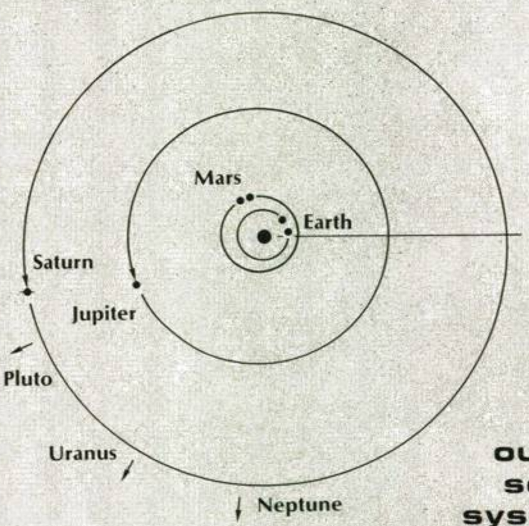
CAP
6
SCO
CMA
SGR
18h
12h
6h
-40°

## inner solar system


Mars
Earth
Mercury
Venus


Mars
Earth
Saturn
Jupiter
Pluto
Uranus
Neptune

## outer solar system

| | | Date | Mag. | Angular Size | % Illum. | Distance (AU) from: Earth | Sun | Longitude: Heliocentric | Ecliptic | R.A. (1981.8) | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sun** | | 1 | -26.7 | 32.0′ | — | 1.00 | — | — | 187°44.1′ | 12h 28.4m | -3°03.9′ |
| | | 15 | -26.7 | 32.1′ | — | 1.00 | — | — | 201°33.3′ | 13h 19.6m | -8°24.0′ |
| | | 31 | -26.8 | 32.3′ | — | 0.99 | — | — | 217°29.3′ | 14h 20.5m | -14°00.4′ |
| **Mercury** | ☿ | 1 | +0.5 | 7.8″ | 44% | 0.86 | 0.42 | 309°48.1′ | 211°39.7′ | 13h 55.7m | -15°29.5′ |
| | | 15 | +2.2 | 10.0″ | 4% | 0.67 | 0.35 | 6°57.2′ | 208°22.1′ | 13h 44.5m | -13°22.6′ |
| | | 31 | 0.0 | 7.4″ | 43% | 0.90 | 0.31 | 101°33.2′ | 199°25.7′ | 13h 14.6m | -5°47.6′ |
| **Venus** | ♀ | 10 | -3.7 | 18.2″ | 64% | 0.91 | 0.73 | 315°26.7′ | 240°40.1′ | 15h 53.9m | -22°39.9′ |
| | | 31 | -3.9 | 22.4″ | 55% | 0.75 | 0.73 | 331°16.5′ | 263°43.5′ | 17h 34.0m | -26°35.6′ |
| **Mars** | ♂ | 15 | +1.7 | 4.7″ | 93% | 1.98 | 1.63 | 116°14.8′ | 145°58.6′ | 9h 56.6m | +14°01.6′ |
| **Jupiter** | ♃ | 15 | -1.2 | 30.5″ | 100% | 6.45 | 5.45 | 200°49.5′ | 200°29.6′ | 13h 18.9m | -7°09.7′ |
| **Saturn** | ♄ | 15 | +1.0 | 15.7″ | 100% | 10.60 | 9.62 | 193°08.2′ | 193°28.9′ | 12h 54.7m | -3°26.7′ |
| **Uranus** | ⛢ | 15 | +6.0 | 3.5″ | 100% | 19.63 | 18.84 | 239°55.6′ | 237°44.6′ | 15h 43.6m | -19°33.9′ |
| **Neptune** | ♆ | 15 | +7.8 | 2.4″ | 100% | 30.74 | 30.27 | 264°12.8′ | 262°11.4′ | 17h 27.9m | -21°57.0′ |
| **Pluto** | ♇ | 15 | +14.0 | — | 100% | 30.96 | 30.01 | 204°15.9′ | 203°43.6′ | 13h 53.7m | +6°02.3′ |

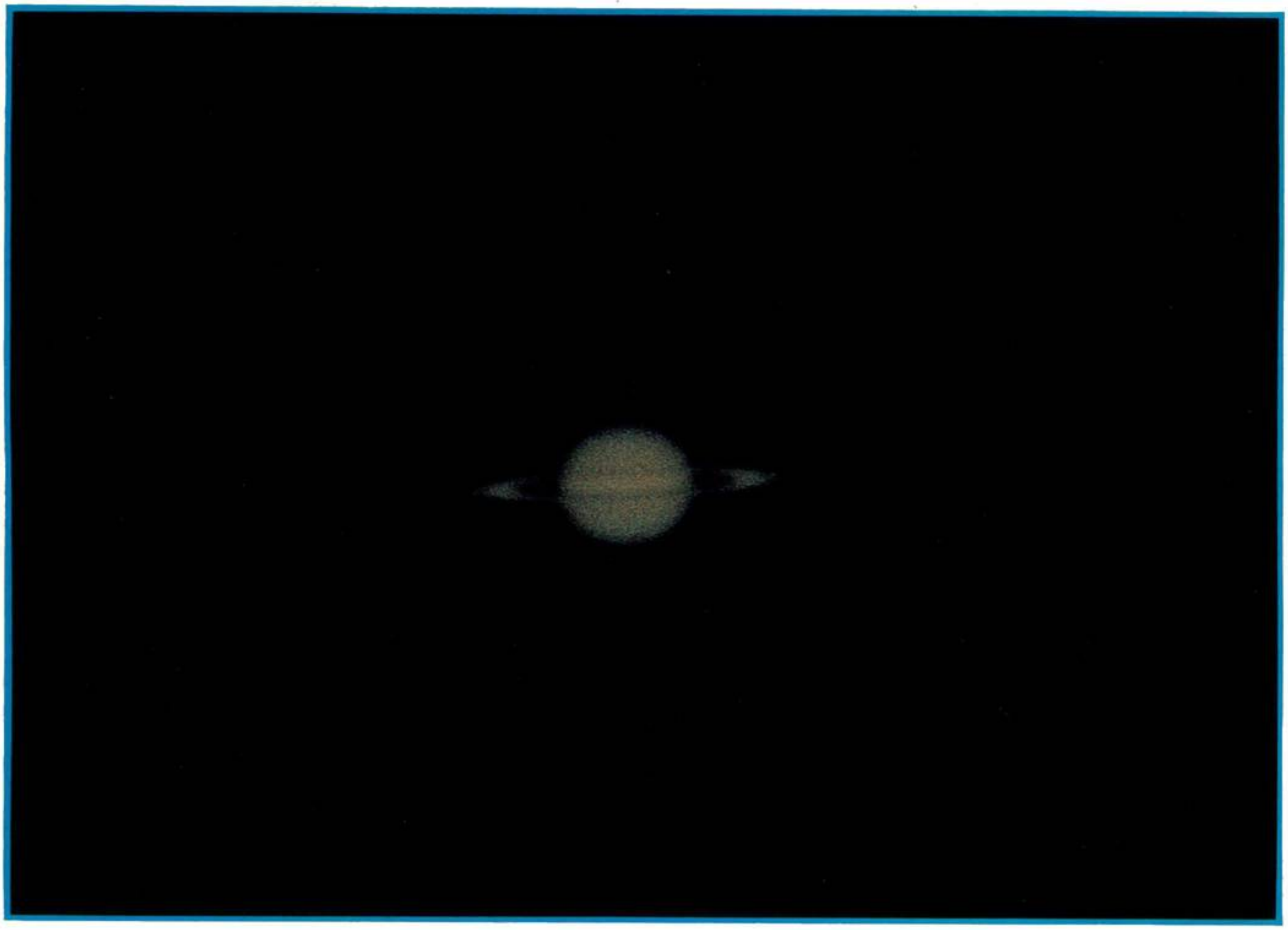
## moon data

| | |
|---|---|
| First Quarter | October 6 at 7:45 |
| Full Moon | October 13 at 12:49 |
| Last Quarter | October 20 at 3:40 |
| New Moon | October 27 at 20:13 |
| First Quarter | November 5 at 1:09 |

| | |
|---|---|
| Apogee: October 3 at 1h | 405,333 km |
| Perigee: October 15 at 2h | 360,481 km |
| Apogee: October 30 at 16h | 406,288 km |

## universal time

Astronomers the world over use an unambiguous system of time reckoning — Universal Time (UT) — based on a 24 hour clock. Times given in Through the Eyepiece are UT unless noted otherwise. To convert UT into your local daylight time, subtract the following number of hours for each time zone: EDT, 4; CDT, 5; MDT, 6; PDT, 7; Alaska, 9. For example, if an event is to happen at 03:00 hours UT on June 7, then EDT for the event is 11 p.m., June 6. Likewise, 03:00 UT on September 2 becomes, in PDT, 8 p.m., September 1.



**A far cry from Voyager, but superb all the same! Jean Dragesco's photograph of Saturn was taken March 11, 1981, about two weeks before opposition, when the ring plane was tipped some 6° to our line of sight. Dragesco used a 4-second exposure at f/60 on 400 ASA slide film; his telescope was a 14-inch Schmidt-Cassegrain.**

sunset. Forty-five minutes after sunset on the 1st, it will be 13° high in the southwest. By the 31st, its elevation will be a scant 2°.

### Neptune

Neptune, one constellation farther east along the ecliptic, will stay out of the Sun's glare for another month. At magnitude 6, the 3.5" of arc disk is slowly moving eastward against the background stars of southern Ophiuchus.

On the evening of October 31st, the planet will lie just to the left of the crescent Moon.

### Meteors

October has two meteor showers of note, the Draconids (which peak on the 10th) and the Orionids (the 20th). The Draconids, as their name implies, appear to come from the constellation Draco. Their radiant point lies in the head of the dragon.

How many you'll see varies greatly depending on where the parent comet (Giacobini-Zinner) happens to be. Displays right after the comet's perihelion have been spectacular, but in off years like this one, the numbers are pretty sparse. A nearly Full Moon will diminish this year's numbers even more — to perhaps 10 an hour.

The situation with the Orionids is about the same. A reliable shower with moderate numbers (25 per hour usually), the Orionids are fast and faint, and some of them leave trains that persist for a few seconds. They appear to come from Orion's raised club. This year, the Moon will be near Last Quarter and its light will drown out most of them.

## close-up on cepheus

Cepheus is a constellation often skipped over in favor of richer star fields to the south. Its disappointing naked eye appearance is probably a result of its proximity to the denser Milky Way regions in Cassiopeia, but don't let this barren section of sky fool you. It is one of the richer autumn regions, and, with a telescope, you'll be able to appreciate its wonders fully.

Cepheus is easy to pick out because its primary stars are equal in magnitude and are the only brighter stars in the area. Its stick figure appearance resembles a house — the old-fashioned kind with the point of the roof at the top. Covering an expanse of almost 600 square degrees in the northern sky, the constellation is ranked 27th of 88 in size. Lying on the fringe of the Milky Way and almost parallel to it, Cepheus is rich in deep-sky objects.

To locate Cepheus, draw a line from Alpha to Beta Cassiopeia and then extend it 18 degrees to the north; you will bisect the constellation. The nearest bright star to Polaris is Gamma ($\gamma$) Cephei a few degrees to the west.

The main stars of Cepheus were named by the Arabs. Alpha ($\alpha$), or Alderamin, a 4th magnitude A5 class star, literally was the "right arm," but now is the shoulder of Cepheus. Beta ($\beta$), also called Alfirk, translates to "stars of the flock" and is a type B1 visual binary with a combined magnitude of 3.3. Gamma ($\gamma$) or Er Rai means the shepherd and is now the left knee of Cepheus. It is spectral type K0 at magnitude 3.9. Spellings may differ for these stars in translations, and in some older atlases they may have completely different names.

A good object to start with is William Herschel's famous Garnet Star — also called **Mu ($\mu$) Cephei**. It is probably the reddest star visible to naked-eye

observers. Its spectral class is M2 and it lies 800 to 1200 light-years from us. The difficulty in determining the distance results from its close proximity to the extensive nebulosity of IC-1396. Mu is the same kind of star as Betelgeuse in Orion, a red giant, and may have a greater actual luminosity than Betelgeuse. At any rate, it ranks as one of the brightest of all red supergiants.

Some observers detect different colors for Mu. Sometimes it appears a deep orange-red and at other times it seems almost purple. James Mullaney and William McCall in their list, *The Finest Deep Sky Objects*, find the star, "almost red in a 3-inch at 45x, deep orange in a 8-inch at 70x and yellow-orange in a 13-inch refractor." The visual range of magnitude varies from 3.7-5.0 with an average period of 755 days. Its variability was first detected in 1848 by J.R. Hind. With the naked eye or with any instrument, Mu Cephei is easily recognized as one of the most colorful stars.

Moving down to **Alpha Cephei**, or Alderamin, we find a small 10.5 magnitude companion 2.6 seconds of arc south of the primary. Alderamin is 52 light-years away and will be the Pole Star in 7,500 A.D.

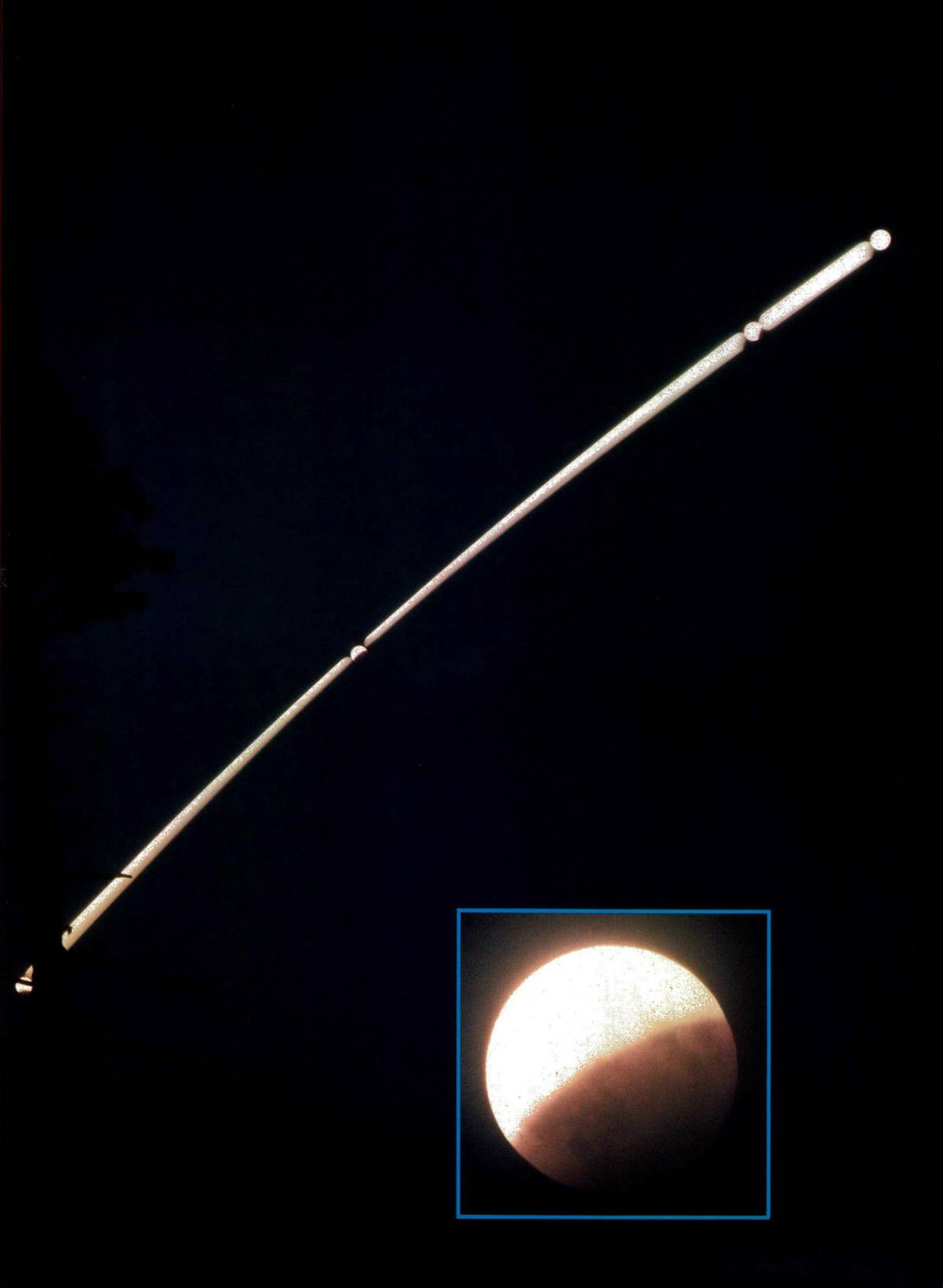
**Beta Cephei**, or Alfirk, shines at magnitude 3.2 and is about 980 light-years distant. Alfirk's actual luminosity is more than 4000 times that of the Sun. Its companion, discovered in 1832 by F.G.W. Struve, has a magnitude of 8.5 and lies 14 seconds of arc away.

Moving along diagonally through the parallelogram, we come to the centrally-located **Xi** ($\xi$) **Cephei**, considered one of the finest doubles in the constellation. At magnitude 4.3, it is 80 light-years distant, and its companion at magnitude 6.5 is located close to the primary. Xi has a space motion similar to the stars in the Hyades Cluster in Taurus and may be an outlying member of that group.

**Above: Roy Gephart photographed the eclipsed Moon over the Columbia River in Washington. Right: Rev. Ronald Royer set his camera at f/90 and let the Moon's image trail across the film for 2½ hours. Inset: Robert Wellauer used a long exposure to bring out details in the umbrally-eclipsed part of the Moon's disk.**

Continuing down the diagonal, we next encounter one of the most famous objects in the whole sky — **Delta** ($\delta$) **Cephei**. To the naked eye this star appears no different than any other, but careful observation over a period of five days will show that its brightness changes by almost a magnitude. This remarkable observation was first made in 1784 by John Goodricke, but the peculiarity of the star was not discovered until the 20th century. Delta Cephei's light variations are not due to eclipses with a companion star — although it has one — but are caused by regular pulsations of the star itself. This variation is easy to see if you keep a careful nightly watch and compare its light to that of nearby Epsilon and Zeta.

Delta Cephei's special properties provide us with a way to measure distance in the universe. Many such stars, now dubbed Cepheid variables, have been observed both in our own Galaxy and in others. Once the actual luminosity of the star is known, the distance can be carefully calculated by comparing the real and apparent brightness. Sometimes called the "measuring sticks of the universe," Cepheids are intrinsically "very brilliant objects" according to Burnham. They can be seen at great distances where stars like the Sun would be dimmed beyond visibility. The discovery of Cepheids in "spiral nebulae" in the 1920s led to the discovery that these objects were external galaxies not unlike the Milky Way.



**Rising high in the northeastern sky by late evening, the large spiral galaxy M-33 in Triangulum can be seen by the naked eye — but only under superbly dark rural skies. Jack Newton took its portrait with a 12½-inch Newtonian telescope and 400 ASA film exposed for 14 minutes at f/4.6 in his home-made cold camera.**

Delta Cephei is an excellent double star for small telescopes. Likened to Alberio in Cygnus, Delta's companion is magnitude 6.3, located 41 seconds of arc away from the primary and shows a definite contrast to the yellowish tinge of the primary. Delta Cephei provides two grand sights: a striking double in the telescope and a pulsating beacon to the naked-eye observer.

Another unusual stellar group lies very close to Delta Cephei. **Krueger 60**, one of the nearest visual binaries, consists of a pair of red-dwarf stars only 13 light-years away. Although it is easily identified in a four-inch scope by its distinct ruddy hue, you'll need six or eight-inches of aperture to fully resolve a third star associated with the grouping — a 10th magnitude field star about 60 seconds of arc from the primary pair. Krueger 60 is a particularly unusual star and has been observed to emit extremely sudden increases in light in as little as two or three minutes. Such stars, called flare stars, are controversial objects. Astronomers think their activities may be similar to normal solar flare activity, but far more violent.

Burnham states that this type of object is extremely rare with only 11 identified to date. Their scarcity might be explained by the odds against anyone observing at the exact time a flare takes place.

Another highly colored although dim object is **S Cephei**. One of the class of carbon stars, this star is even cooler than a red giant and varies in magnitude from 7.5 at maximum to 12.5 at minimum over a period of 18 months. Burnham states, "S Cephei is one of the deepest colored stars visible to observers with small and moderate sized telescopes. Its intense shade of red makes it a vivid object in the field of any good instrument." Lalande discovered this star in October 1789.

For relief from observing so many abnormal stellar attractions, swing your scope around almost to the Pole. Four degrees away from Polaris you will find the oldest known galactic or open cluster, **NGC-188** which measures 15 seconds of arc in diameter, contains 150 stars, and lies about 500 light-years from us. Dark skies and a low-power ocular give the best views of NGC-188, and in an RFT it is breath-taking. No young stars have ever been detected in this cluster, and its brightest 10 stars are yellow giants. The cluster's age was originally estimated at 24 billion years, but recent calculations suggest it is closer to 14 billion. At any rate, we are observing a very ancient assemblage of stars that blazed out into a night sky long before the Earth itself had cooled.

This cluster was first discovered by John Herschel (son of William) who described it as "very large, round, with perhaps 150-200 stars of 10th to 18th magnitude." Their combined light equals that of a 9th magnitude star. NGC-188 is classified as a very loose and irregular cluster having many properties of a globular, but lacking the compact nature. About 70 stars can be glimpsed in medium-sized scopes on dark nights with low magnifications of 50 and 100x. Once you've found this ancient cluster, don't simply log it as another notch for your tube and move on.

An unusual grouping of objects lies on the Cepheus/Cygnus border just two degrees south of Eta ($\eta$) Cephei. **NGC-6946** (a large Sc-type spiral galaxy) and NGC-6939, an open cluster, appear very close and in a low-power ocular may even be in the same field of view. Only 39 seconds of arc separates these objects. NGC-6946 is 11th magnitude, but has a very low surface brightness due to its eight seconds of arc diameter. Appearing circular to the eye, the nucleus is the only detail visible. The brighter haze of the spiral arms will be seen by those observers with large scopes (10 inches and up). Long exposures taken by observatory telescopes resolve the arms into clumpy strands of stars and nebulosity. The most prominent arm may be glimpsed extending about five seconds of arc from the northeast side of the nucleus. It ends in several bright patches of nebulosity which may be observed as more haze in one particular area.

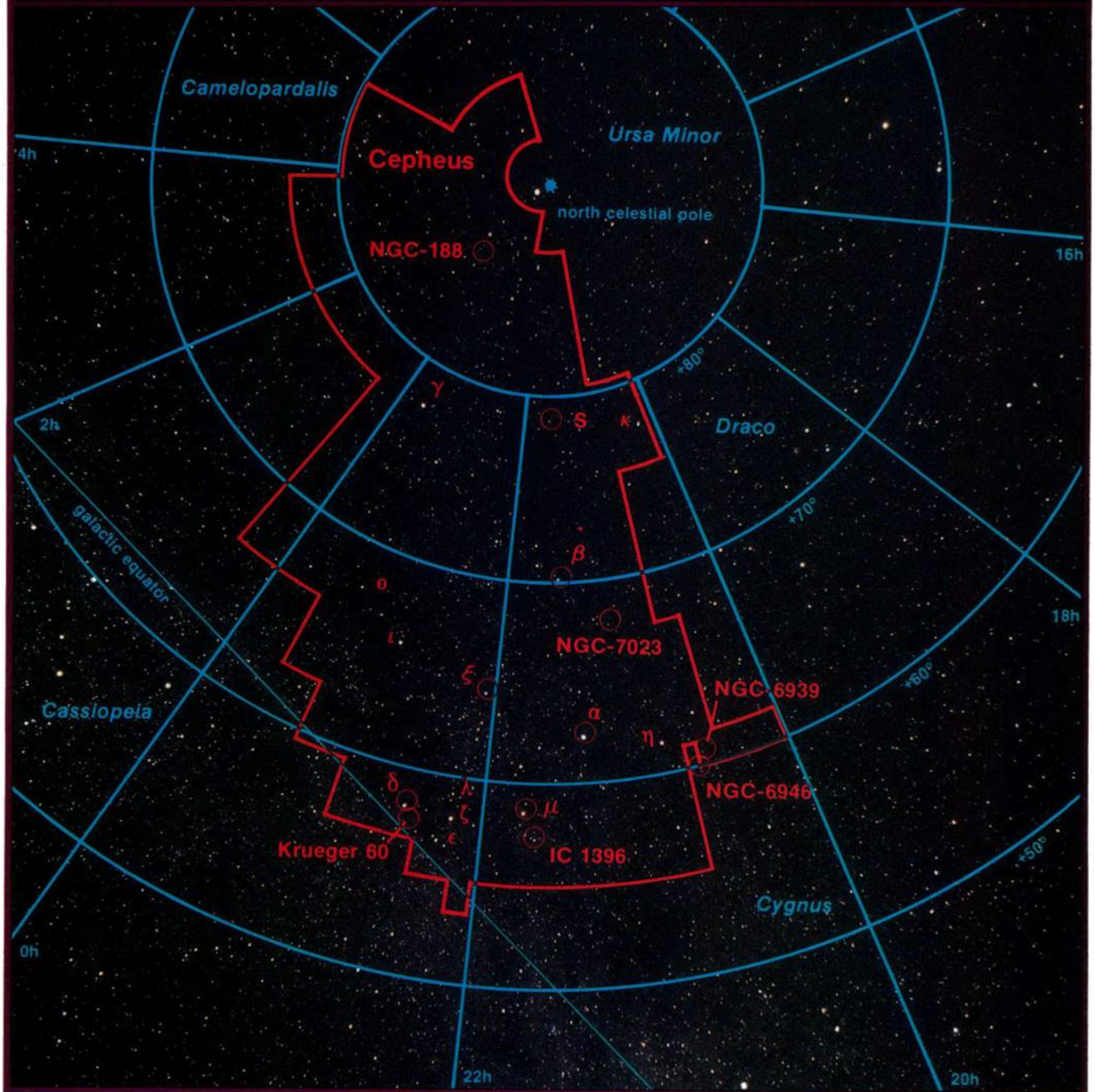
NGC-6946 is one of the nearest galaxies beyond what is called our Local Group, and was thought to be a member for a long time. Also, there have been four supernovae observed in this galaxy since 1917, making it one of the most active sites for supernovae.

Also in Cepheus is **NGC-7023**, a 7th magnitude diffuse nebula 18 seconds of arc across. Burnham described it as being "bright and dark with masses and outer filaments; complex in structure." NGC-7023 will test your skills at locating dim objects, but if you've got the time and the night is dark, give it a try. You can see it in a 6-inch but of course larger instrument would be preferred. Any of these objects within the constellation of Cepheus would be excellent to photograph. If you get good shots of any of them, why not send them to us?

# cepheus

photo by Brad Wallis & Robert Provin

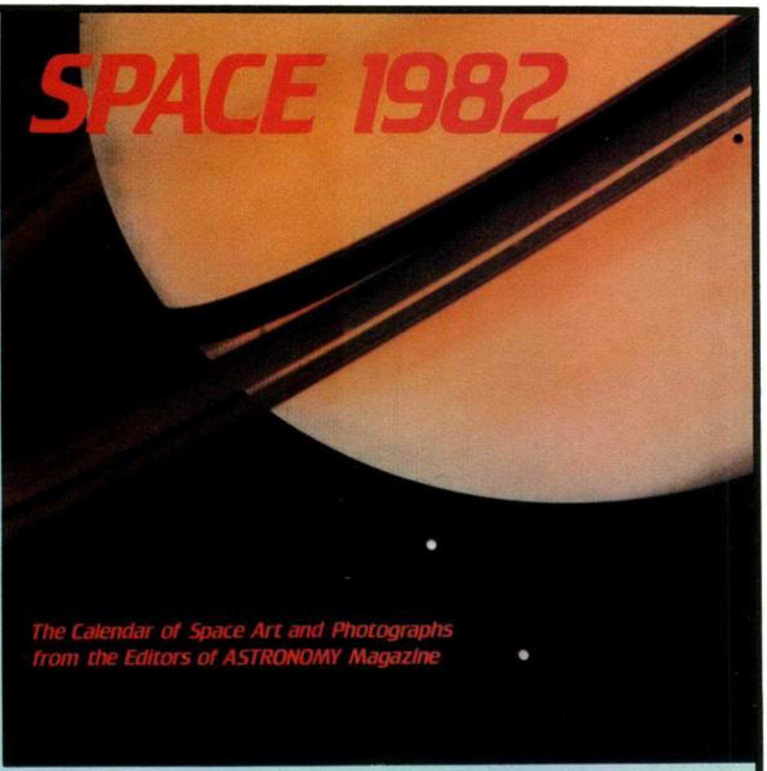
map by Robert Burnham


Camelopardalis
Cepheus
Ursa Minor
north celestial pole
4h
NGC-188
16h
+80°
2h
γ
S
κ
Draco
+70°
galactic equator
β
θ
18h
ι
NGC-7023
ξ
+60°
NGC-6939
Cassiopeia
α
η
δ
λ
NGC-6946
ζ
μ
Krueger 60
ε
IC 1396
+50°
Cygnus
0h
22h
20h

| Object | Type | Mag. | Size/Sep. Per. | R.A. (1950) | Dec. | R.A. (1981) | Dec. |
|---|---|---|---|---|---|---|---|
| NGC-188 | ○ | 9.3 | 15″ | 00h 39m | +85°03′ | 00h 43m | +85°14′ |
| NGC-6939 | ○ | 10.0 | 8′ | 20h 30m | +60°28′ | 20h 31m | +60°34′ |
| NGC-6946 | §S | 9.0 | 8′ | 20h 34m | +59°58′ | 20h 35m | +60°04′ |
| NGC-7023 | □ | 7.0 | 18′ | 21h 01m | +67°58′ | 21h 02m | +68°05′ |
| Alpha ($\alpha$) | ★ | 2.5,10.5 | 2.6″ | 21h 17m | +62°22′ | 21h 18m | +62°30′ |
| Beta ($\beta$) | $★^2$ | 3.3,8.5 | 14″ | 21h 28m | +70°20′ | 21h 86m | +70°29′ |
| S | ጠ★ | 7.5-12.5 | 487d | 21h 36m | +78°24′ | 21h 36m | +78°32′ |
| IC 1396 | □ | 5.6 | 165′x 135′ | 21h 38m | +57°14′ | 21h 38m | +57°22′ |
| Mu ($\mu$) | ጠ★ | 3.7-5 | 755d | 21h 42m | +58°33′ | 21h 43m | +58°42′ |
| Xi ($\xi$) | $★^2$ | 4.3,6.5 | 8″ | 22h 02m | +64°23′ | 22h 03m | +64°32′ |
| Krueger 60 | $★^3$ | 10,11,10 | 2″,60″ | 22h 26m | +57°27′ | 22h 28m | +57°36′ |
| Delta ($\delta$) | ጠ★ | 3.6-4.3,6.3 | 5.4d/41″ | 22h 27m | +58°10′ | 22h 18m | +58°19′ |

| | |
|---|---|
| ★ | *Star* |
| $★^2$ | *Double Star* |
| $★^3$ | *Triple Star* |
| ጠ★ | *Regular Variable* |
| ∩★ | *Irregular Variable* |
| Ӿ★ | *Eclipsing Variable* |
| ○ | *Open Cluster* |
| ● | *Globular Cluster* |
| ■ | *Planetary Nebula* |
| □ | *Bright Diffuse Nebula* |
| §0 | *Elliptical Galaxy* |
| §S | *Spiral Galaxy* |
| §ʃ | *Barred Spiral Galaxy* |
| §# | *Peculiar/Irregular Galaxy* |

# ASTRONOMY'S SPACE 1982 CALENDAR


SPACE 1982
The Calendar of Space Art and Photographs
from the Editors of ASTRONOMY Magazine

The Sun.

The Moon.

The Planets.

Beyond the Milky Way
to the Nebulae where
Stars are born.

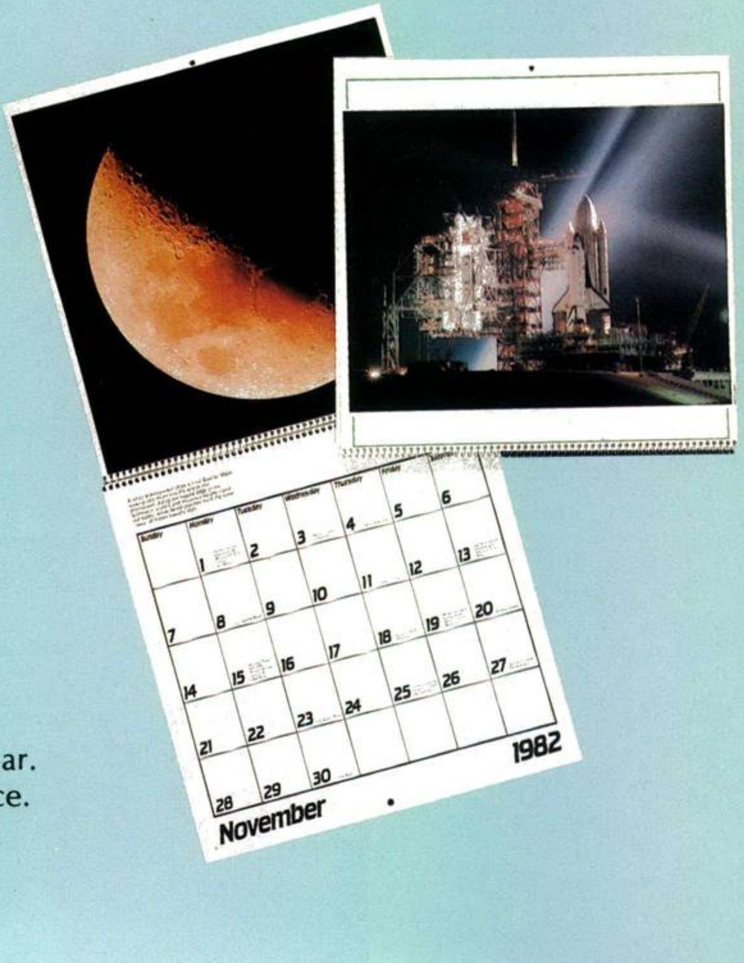
ASTRONOMY's all new
Space 1982 Calendar
takes you to these
exotic places...

With colorful paintings
by today's finest space artists

With detailed NASA photos
made by Voyager on its
odyssey to Jupiter and Saturn

With a liftoff photo
of the Shuttle Columbia —
our first true spaceship

— 14 beautiful images
suitable for framing, plus
notable dates in astronomy
and space science.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# Look Into The Dynamax Schmidt-Cassegrain Telescope. See What You're Missing.

If you have yet to look into the Dynamax Schmidt-Cassegrain telescope, we strongly urge you to do so.

Because until you do, here's what you'll be missing:

**A Schmidt-Cassegrain system with oversized primary mirror and Schmidt-plate-only image correction. To give you full-field illumination as well as the greatest possible freedom from aberrations and color imbalance off axis.**

Diffraction-limited optics so smooth of overall figure that the quality of the total system exceeds even professional demands.

**A galaxy of added-performance features not available with any other Schmidt-Cassegrain of comparable size.**

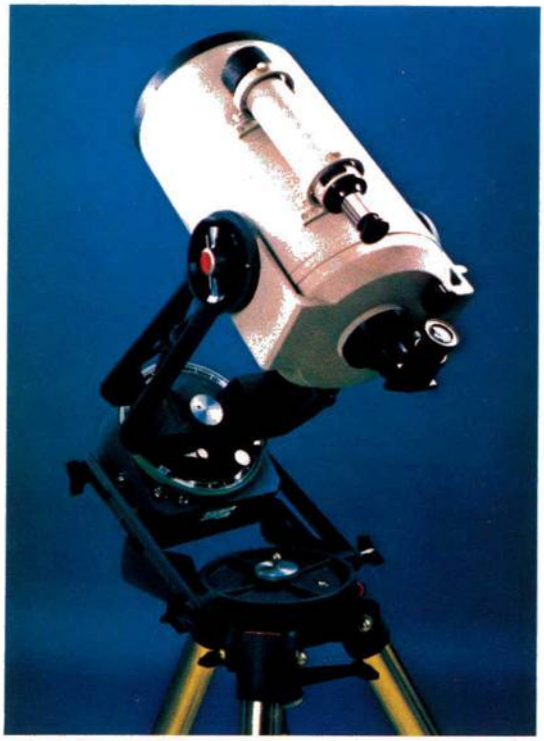
Like expansion-proof, non-conducting, oversized tube, for total dimensional and thermal stability —a tube that won't expand or contract like aluminum—a tube so strong the military fires rockets from it.

**Like rugged *sand-cast* aluminum construction; inside-stress-cantilever fork arms; heavy-duty, self-centering polar ball bearings; fully enclosed clock-drive system.**

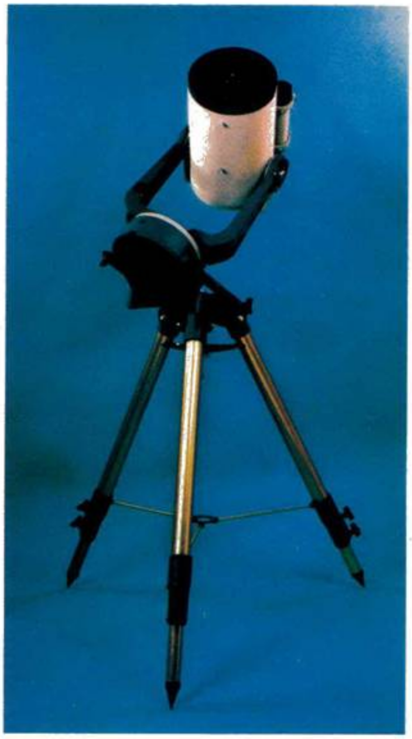
Like radially adjustable R.A. slow-motion control, dual-knob Dec. slow-motion control, setting circles readable from the observer's position, multipurpose R.A. setting circle.

**And there's more.**

We talk about it in our new 16-page color catalog, which features photos taken through the Dynamax. The catalog is yours for the asking. Write for it today.



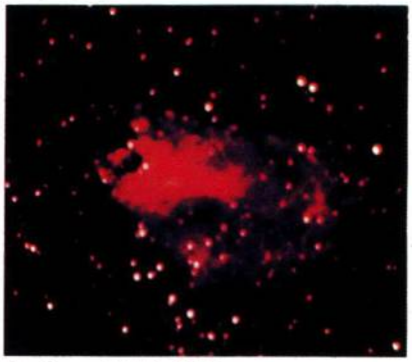
Rear view of the Dynamax 8 mounted on Dynamax Field Tripod



Front view of the Dynamax 8 mounted on field tripod

## Dynamax Price Increase

Due to the tremendous response to our recent price announcement we are extending the present price to orders postmarked prior to June 15, 1981. Effective June 15, the price will be increased to $949.95.



The Omega Nebula (M17) as photographed through the Dynamax 8.

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Worth Looking Into

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# Celestron 90 Photographs

## PRICE ANNOUNCEMENT

The C90 Instruments will be going up in price effective October 15, 1981. Please contact your nearest Celestron dealer for pricing information.

Spider spinning a web

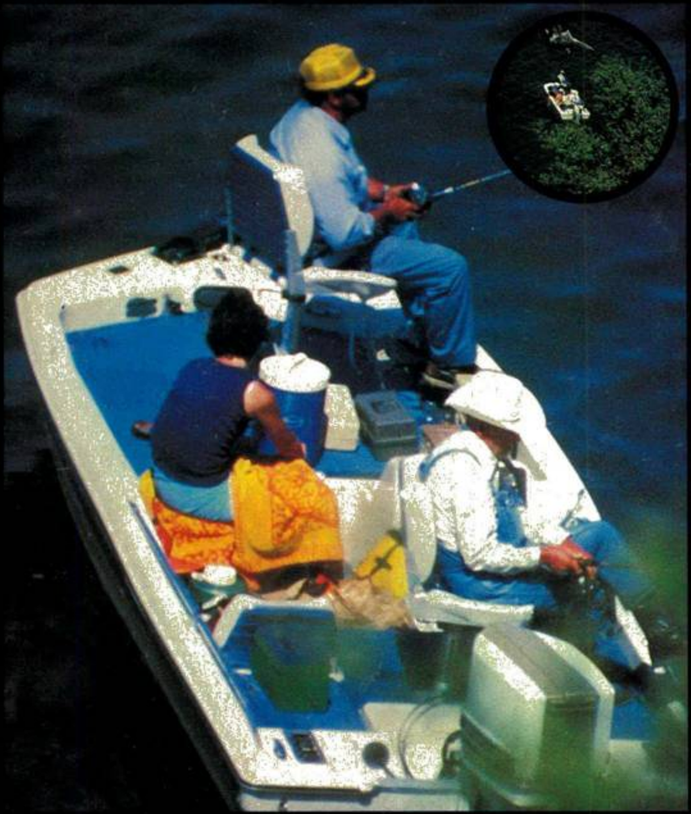
Fox squirrel at 50 feet

Grasshopper

Rhino

Eagle

Leopard


A fishing boat (inset — 50mm comparison)

The lunar landscape

The C90 is the most popular instrument in this size aperture. For details on the three models available see inside pages of this magazine.

**Makes an ideal Christmas present for someone special.**

For a completely updated 52-page catalog on all Celestron products, please send $3.00 to: Celestron International, 2835 Columbia St., Box 3578-B, Torrance, CA 90503 (213) 328-9560